THIRTY-SIXTH ANNUAL REPORT

OF THE

Maine Agricultural Experiment Station

ORONO, MAINE

1920

UNIVERSITY OF MAINE

1920

MAINE
AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE

ORGANIZATION JANUARY TO JUNE, 1920

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MAINE
AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE

ORGANIZATION JULY TO DECEMBER, 1920

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THE STATION STAFF

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	HUGH C. McPHEE, B. S.,	*Scientific Aid*
ROYDON L. HAMMOND,		*Seed Analyst and Photographer*

The publications of this Station will be sent free to any address in Maine. All requests should be sent to

Agricultural Experiment Station,
Orono, Maine.

CONTENTS.

ANNOUNCEMENTS.

Establishment of the Station

The Maine Fertilizer Control and Agricultural Experiment Station, established by Act of the Legislature approved March 3, 1885, began its work in April of that year in quarters furnished by the College. After the Station had existed for two years, Congress passed what is known as the Hatch Act, establishing agricultural experiment stations in every state. This grant was accepted by the Maine Legislature by an Act approved March 16, 1887, which established the Maine Agricultural Experiment Station as a department of the University. The reorganization was effected in June, 1887, but work was not begun until February 16, 1888. In 1906, Congress passed the Adams Act for the further endowment of the stations established under the Hatch Act.

The purpose of the experiment stations is defined in the Act of Congress establishing them as follows:

"It shall be the object and duty of said experiment stations to conduct original researches or verify experiments on the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantage of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and water; the chemical composition of manure, natural and artificial, with experiments designed to test their comparative effects on crops of different kinds; the adaptation and value of grasses and forage plants; the composition and digestibility of the different kinds of food for domestic animals; the scientific and economic questions involved in the production of butter and cheese; and such other researches or experiments bearing directly on the agricultural industry of the United States as may in each case be deemed advisable, having due regard to the varying conditions and needs of the respective states or territories."

The work that the Experiment Station can undertake from the Adams Act fund is more restricted and can "be applied only to paying the necessary expenses for conducting original researches or experiments bearing directly on the agricultural industry of the United States, having due regard to the varying conditions and needs of the respective states and territories."

INVESTIGATIONS.

The Station continues to restrict its work to a few important lines, believing that it is better for the agriculture of the State to study thoroughly a few problems than to spread over the whole field of agricultural science. It has continued to improve its facilities and segregate its work in such a way as to make it an effective agency for research in agriculture. Prominent among the lines of investigation are studies upon the food of man and animals, the diseases of plants and animals, breeding of plants and animals, orchard and field experiments, poultry investigations, and entomological research.

INSPECTIONS.

Up to the close of the year 1913, it had been the duty of the Director of the Station to execute the laws regulating the sale of agricultural seeds, apples, commercial feeding stuffs, commercial fertilizers, drugs, foods, fungicides and insecticides, and the testing of the graduated glassware used by creameries. Beginning with January, 1914, the purely executive part of these laws is handled by the Commissioner of Agriculture. It is still the duty of the Director of the Station to make the analytical examination of the samples collected by the Commissioner and to publish the results of the analyses. The cost of the inspections is borne by fees and by a State appropriation.

OFFICES AND LABORATORIES.

The offices, laboratories and poultry plant of the Maine Agricultural Experiment Station are at the University of Maine, Orono. Orono is the freight, express, post, telegraph and telephone address for the offices and laboratories.

AROOSTOOK FARM.

By action of the Legislatures of 1913 and 1915 a farm was purchased in Aroostook County for scientific investigations in agriculture to be under "the general supervision, management, and control" of the Maine Agricultural Experiment Station. The farm is in the town of Presque Isle, about 2 miles south of the village, on the main road to Houlton. The Bangor and Aroostook railroad crosses the farm. A flag station, "Aroostook Farm," makes it easily accessible by rail.

The farm contains about 275 acres, about half of which is cleared. The eight room house provides an office, and home for the farm superintendent. A school house on a lot adjoining the farm was presented to the State by the town of Presque Isle and after being remodeled serves as a boarding house for the help. A greenhouse and a potato storage house have been erected at the farm by the U. S. Department of Agriculture for use in cooperative work on potato breeding. The large barn affords storage for hay and grain and has a large potato storage house in the basement.

HIGHMOOR FARM.

The State Legislature of 1909 purchased a farm upon which the Maine Agricultural Experiment Station was directed to "conduct scientific investigations in orcharding, corn and other farm crops." The farm is situated largely in the town of Monmouth. It is on the Farmington Branch of the Maine Central Railroad, 2 miles from Leeds Junction. A flag station, "Highmoor," is on the farm.

The farm contains 225 acres, about 200 of which are in orchards, fields, and pastures. There are in the neighborhood of 3,000 apple trees upon the place which have been set from 20 to 30 years. The house has 2 stories with a large wing, and contains about 15 rooms. It is well arranged for the Station offices and for the home of the farm superintendent. A substantially constructed building for apple packing was erected in 1912.

The removal of the crossbred herd from the University to Highmoor necessitated considerable change in the barns and the building of a new one 80 x 36 to accommodate the herd. This

barn has a basement for manure, the cow stanchions above, and a loft for storage of hay. The silo has been enlarged and a long shed has been made into calf pens. A well to supply the necessary water has been driven.

PUBLICATIONS.

The Station is organized so that the work of investigation is distinct from the work of inspection. The results of investigation are published in the bulletins of the Station and in scientific journals, both foreign and domestic. The bulletins for the year make up the annual report. The results of the work of inspection are printed in publications known as Official Inspections. These are paged independently of the bulletins and are bound in with the annual report as an appendix thereto. Miscellaneous publications consisting of newspaper notices of bulletins, newspaper bulletins and circulars which are not paged consecutively and for the most part are not included in the annual report are issued during the year. Weekly mimeograph publicity letters are sent to all papers within the State.

BULLETINS ISSUED IN 1920.

No. 285. Wheat Investigations. I. Pure Lines. 48 pages. 3 pages of plates.

No. 286. The Variation of Milk Secretion with Age in Jersey Cattle. 9 pages.

No. 287. Self Sterility and Cross Sterility in the Apple. 20 pages.

No. 288. Some Observations Upon the Effect of Borax in Fertilizers. 33 pages.

No. 289. The Correlation Between Milk Yield of One Lactation and That of Succeeding Lactations. 10 pages.

No. 290. The Variation of Butter-Fat Percentage with Age in Jersey Cattle. 12 pages.

No. 291. The Correlation Between the Butter-Fat Percentage of One Lactation and Succeeding Lactations in Jersey Cattle. 9 pages.

No. 292. Potato Mosaic. 28 pages.

No. 293. Studies in Milk Secretion VIII. Influence of Age on Milk and Butter-Fat Yield in Holstein-Friesian Cattle. 13 pages.

No. 294. Normal and Abnormal Germination of Grass-Fruits. 19 pages. 4 pages of plates.

No. 295. Abstracts of Papers not included in Bulletins, Finances, Meteorology, Index.

OFFICIAL INSPECTIONS ISSUED IN 1920.

No. 95. Drugs and Foods. 28 pages.
No. 96. Commercial Feeding Stuffs, 1919-20. 37 pages.
No. 97. Commercial Fertilizers, 1920. 25 pages.
No. 98. Commercial Agricultural Seeds, 1920. 25 pages.

MISCELLANEOUS PUBLICATIONS ISSUED IN 1920.

No. 538. The Relation of Conformation to Milk Yield in Jersey Cattle. 12 pages.
No. 539. Improved Strains of Aroostook Grown Wheats. 11 pages.

BIOLOGICAL PUBLICATIONS, 1920.

In the numbered series of "Papers from the Biological Laboratory":

132. Wheat Investigations. I. Pure Lines. By Jacob Zinn. Annual Report of the Maine Agricultural Experiment Station for 1920. Bulletin 285, pp. 1-49.
133. Self Sterility and Cross Sterility in the Apple. By John W. Gowen. Annual Report of the Maine Agricultural Experiment Station for 1920. Bulletin 287, pp. 61-89.
134. Studies in Milk Secretion VIII. On the Influence of Age on Milk Yield and Butter-Fat Percentage, as Determined from the 365 day Records of Holstein-Friesian Cattle. By John W. Gowen. Annual Report of the Maine Agricultural Experiment Station for 1920. Bulletin 293, pp. 185-196.
135. Inheritance in Crosses of Dairy and Beef Breeds of Cattle. II. On the Transmission of Milk Yield to the First Generation. By John W. Gowen. Journal of Heredity.
136. Inheritance in Crosses of Dairy and Beef Breeds. III. Transmission of Butter-Fat Percentage to the First Generation. By John W. Gowen. Journal of Heredity.

ENTOMOLOGICAL PAPERS, 1920.

Ent. No. 106. The Life Cycle of Aphids and Coccids. By Edith M. Patch. Annals Entomological Society of America, Vol. 13, No. 2. pages 156-167.

STATION NOTES.

COUNCIL AND STAFF CHANGES.

At the June meeting of the Trustees Mr. Chas. E. Oak and Mr. Thomas E. Houghton were appointed to represent the

Board of Trustees on the Station Council in place of Frank E. Guernsey and Chas. S. Bickford.

Roydon L. Hammond, Seed Analyst and Photographer, resigned on October 1, to accept a similar position with the Delaware State Department of Agriculture.

Dr. Raymond Pearl, Collaborating Biologist for the Station, resigned this position in June. The poultry records and much other material which he was preparing for publication in bulletins of the Maine Station were all lost in a fire which destroyed the old group of buildings at Johns Hopkins University early in the year.

On December 1st, after nearly twenty-five years of efficient service as Director of the Maine Experiment Station, Dr. Chas. D. Woods' term of office was abruptly terminated. This unfortunate occurrence came at a very inopportune time. The year's work had been nearly completed but the Annual Report which was always arranged by him had not been prepared. The Report consists largely of bulletins issued at intervals through the year giving the results of most of the work done by the Station. The Director, however, carried on some experimental work under his own supervision the results of which no one else was very familiar. This had not been prepared for publication and is consequently omitted from the Report.

SOIL TEST EXPERIMENT.

The soil test experiment at Aroostook Farm which was started in 1916 is still in progress. A new piece of land, however, has been taken for the purpose. The first piece selected gave such uneven yields that we were forced to the conclusion that the soil lacked the necessary uniformity for this type of work. The new piece was divided into plots and planted to potatoes in 1919, without fertilizer, to test its uniformity. The yields (on the different plots) were quite uneven but whether these differences were due to previous treatments and will disappear with further cropping cannot now be told. In 1920 all the plots were dressed with ground limestone, sowed to oats and seeded down to clover. The yields of oats were somewhat more even than those of the potatoes but not so even as desirable and further cropping may be necessary before the experiment with chemicals can be begun.

BULLETIN 285

WHEAT INVESTIGATIONS. I. PURE LINES.[1]

By Jacob Zinn.

SUMMARY

The present bulletin contains an account of the origin and development of a number of pure lines of wheat by the method of selection, including data on all the important stages, except milling, from the single head selection to the bakehouse. The study of the effect of the environment of Northern Maine upon the physical and chemical characteristics of pure strains introduced from Minnesota forms an incidental feature of this report.

In 1915 several hundred wheat spikes were selected from commercial varieties representing the chief groups of hard red spring wheat. Of these selections 259 heads were retained and each grown in a row in the cereal crop nursery in 1916. In the following year 91 strains of the original selections were grown in one two-thousandth acre plots, along with 7 pure strains introduced from Minnesota. The crop from the one two-thousandth acre plots furnished enough seed to make a chemical determination of the crude protein content of each strain. In 1918 only 44 pure lines selected from Aroostook wheats and 6 lines of Minnesota wheats were retained and grown in plots ranging from one two-hundredth to one-fortieth acre in area. A complete chemical analysis of the wheat and flour of 37 lines and a baking test of 31 lines were made in the spring of 1919.

Under the same conditions of environment the pure lines of wheat showed distinct differences in the physical and chemical characteristics and in the bread making value of their grain.

The average weight per 1000 kernels for all lines was found to be 35.314 grams. The individual strains within a variety showed a very considerable variation in the weight per 1000

[1]Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 132.

kernels—ranging from 26.541 to 44.789 grams—as well as a marked deviation from the average of their respective parent varieties. The strains with the highest weight per 1000 kernels produced the greatest percentage of yellow berries and yielded flours of poor baking quality. The environmental conditions prevailing in Aroostook brought the low kernel weight of the original Minnesota seed up to the level of the Aroostook strains within a single season. This change, however, was not found to be progressive.

The data on the yield, though very limited, show a number of strains of high yielding capacity. Each variety furnished high and low yielding strains the differences in yield between the lines of the same variety being greater than between varieties.

The average protein content of the Aroostook lines was 13.81 and 12.62 per cent for the season of 1917 and 1918, respectively. The Canada Red (Ladoga type) and Preston strains yielded the highest, the Marquis the lowest protein content.

A study of the relationship between the protein content of the pure lines in 1917 and 1918 revealed a tendency for the varieties as well as for the strains to retain their relative rank with respect to protein content from one year to the next. The coefficient of correlation between the protein content of the pure strains in 1917 and 1918 was found to be $0.381 \pm .092$.

Certain strains of bread wheats introduced from Minnesota retained their high protein content under Aroostook conditions. The average protein content of the Aroostook grown Minnesota bread wheats was somewhat higher than that of the Aroostook pure lines for two successive seasons. The durum strains, however, showed a very rapid deterioration. The Minnesota grown durum strain, Speltz Marz, headed the list of the Minnesota introductions in regard to protein content; at the end of a single season's growth in Aroostook this line showed the second lowest protein content of all 99 strains analysed. The second durum strain, Hedge Row, showed the lowest protein content of all lines at the end of the first season under Aroostoook conditions. The low protein content was accompanied by the production of a very high percentage of yellow berries.

A number of the pure lines showed a high gluten content, the Preston strains ranking highest being followed by the Minnesota, Red Fife, Canada Red, Bluestem, and Marquis lines in

the order named. The Red Fife and Bluestem furnished a number of strains with good quality glutens while the Preston and Marquis yielded a large percentage of strains with fair to poor quality of gluten. The Minnesota lines, with the exception of the durum and Marquis wheat yielded a strong elastic gluten of good quality.

The baking test showed very marked variations in the flour strength of the different pure lines, the volume of bread loaf, baked from 340 grams of flour, ranging from 1518 to 2221 cubic centimeters. A number of strains produced bread possessing a good volume and very good appearance, good to very good texture and color of crumb, and excellent eating qualities. Some of the Minnesota strains produced a very good volume and showed very good baking quality.

The available data indicate that strains of wheat of good quality can be isolated and successfully grown under Aroostook conditions.

INTRODUCTION.

One of the most perplexing problems connected with agricultural crops is the quality of wheat. Though wheat has perhaps a wider range of distribution throughout the world than any other crop, yet the regions in which strong wheats of best quality are successfully grown, are very distinct and rather limited. This relation between the quality of wheat and the environment is of greatest concern primarily to the plant breeder who attempts the improvement of the strength of wheat in regions outside the natural districts of the hard red wheats. It is a well known fact that the majority of wheats grown in the forested regions of the northeast are at best semi-hard and do not come up in their bread-making quality to the high standards of the wheats grown in the prairie regions of the Northwest and Russia. As a direct effect of the influence of the environment upon the wheat grain it has been frequently observed that when some of the hard vitreous wheats from the prairie regions are introduced into localities marked by a cool summer, abundant rainfall and high relative moisture, they tend to lose their translucency and horny texture and assume a plump, dull opaque appearance.

As the baking quality or strength of wheat has been commonly regarded as being determined by the chemical composition, the problem of strength in wheat has long been studied from the chemical point of view. Two aspects of this problem were especially subjected to a frequent study, viz., the relation between the chemical composition and the bread-making value, and the influence of the environment upon the chemical composition of wheat. In the first stage of the study of the relation between the chemical composition and strength the quantity of protein and gluten was regarded as the determining factor of strength. As the accumulating evidence on this point was not concordant the investigators in this field turned to the study of the quality of gluten, notably its chemical quality. Various theories have been suggested in explanation of the strength of wheat, such as the gliadin number i. e. the ratio of gliadin to glutenin, the absolute amount of gliadin in the flour, the ratio of nitrogen to available potassium, the nitrogen in amino form, the ratio of total nitrogen to soluble nitrogen in flour, enzymic activity, etc. The study of the physical properties of the gluten gained an impetus since the work of T. B. Wood[2], who after establishing that the gliadin and glutenin of strong and weak flours were identical, found that the strength of wheat flour "is associated with a high ratio of proteid to salt and that the size of the loaf depends in the first instance on the amount of sugar contained in the flour together with that formed in the dough by diastatic action."

In studying the extensive literature on the chemistry of the strength in wheat one must be impressed with the marked divergence of views on this problem despite the careful work and standard analytical methods. In view of this the plant breeder is naturally inclined to suspect the heterogeneous nature of the material as being responsible for the conflicting results. For in the study of the chemistry of strength the individuality of the wheat variety that furnished the flour, its inherent specific influence upon the baking value, has been generally neglected. And yet it would seem more reassuring to the plant breeder if in the investigation of such a subtile problem as strength in wheat an inductive rather than deductive procedure be adopted

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[2]Wood, T. B. The Chemistry of Strength of Wheat Flour. Jour. Agric. Sci. 1907 Pt. I., pp. 139-160 and II pp. 267-277.

by analyzing a given variety of wheat into its component strains and determining the behavior of the flour from each strain under identical conditions. In tracing down the specific behavior of the flour from isolated, individual strains or pure varieties certain varietal features may be established which otherwise may completely elude detection in the analysis of commercial samples of flours furnished by different wheat varieties. Whatever the cause of the discordant results, the fact remains that at the present time there is no commonly accepted, reliable chemical formula that could guide the plant breeder in detecting the strength in wheat.

The plant breeder who attempts the improvement of the wheat quality in regions outside the natural wheat lands will find still less encouragement if he turns to results and conclusions bearing on the influence of the environment upon the chemical composition of wheat. Here, again, the opinions of the workers are at variance. Without reviewing here the extensive literature relative to the question of climate and soil relations to the chemical composition it may be stated that the majority of investigators, notably Lyon[3], Thatcher[4], Le Clerc and Leavitt[5], Shaw and Walters[6], Le Clerc and Yoder[7], consider the climate as the predominating factor controlling the chemical composition of wheat to the negligence or even exclusion of the soil factors. As an interesting event in this connection it may be noted that the agronomic workers who met in the third western agronomic conference at Cornwallis, Oreg. 1918, agreed that quality of wheat was dependent on both soil and climatic conditions.[8]

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[3]Lyon, T. L. Improving the Quality of Wheat. U. S. D. Agr. Bur. Plant Ind. 1905 Bull. 78, pp. 1-120.

[4]Thatcher, R. W. The Chemical Composition of Wheat. Wash. Agr. Exp. Sta. Bull. No. 111, pp. 1-79, 1913.

[5]Le Clerc, J. A. and Sherman Leavitt. Tri-local Experiments on the Influence of Environment on the Composition of Wheat, 1910. U. S. Dept. Agr. Bur. Chem. Bull. 128 pp. 1-18.

[6]Shaw, C. W. and Walters, E. H. A Progress Report Upon Soil and Climatic Factors Influencing the Composition of Wheat. Cal. Agric. Exp. Sta. Bull. 216. pp. 549-574, 1911.

[7]Le Clerc, J. A. and Yoder, P. A. Environmental Influences on the Physical and Chemical Characteristics of Wheat. 1914. Jour. Agr. Res. V. I, No. 4, pp. 275-291.

[8]Jour. Am. Soc. Agr. V. 10, No. 7-8, 1918, p. 312.

As in the study of the relation of chemical composition to quality so also in most of the investigations into the effect of environment upon chemical composition very little significance was attached to the seed as a factor influencing the composition of the crop. The conclusions reached in these investigations are well reflected in Le Clerc's statement that "soil and seed play a relatively small part in influencing the composition of crops." (L.c. 1910 p. 18), and that "environment rather than what has been usually termed heredity is the major factor in determining the physical and chemical characteristics of the wheat crop." (L.c. 1914, p. 291).

In view of the generally accepted relation between the chemical composition and quality of wheat these results may become of some concern to the plant breeder. However, in this and similar work again the conclusions are based on the evidence obtained from samples of commercial varieties of wheat. The few experiments with pure strains of wheat entering into this work were concerned with the cumulative effect of selection rather than with the selection and retention of prepotent strains. A common feature of most of the older publications on the influence of environment upon the chemical composition is that they are not accompanied by baking tests, hence do not bear directly on the quality of wheat.

With the advent of the modern principles of plant breeding a third factor, namely, the inherent characteristics of the different varieties and strains, entered into the consideration of causes influencing the quality of wheat. The first important question confronting the plant breeder was, whether the quality of wheat was merely a function of the environment indiscriminately levelling it regardless of the individual characteristics of the different varieties or strains. Biffen[9] first subjected the physical characters associated with strength to a genetic analysis and found that "strength" and "weakness" form a pair of Mendelian characters. Upon these theoretical results a number of hard, crossbred strains have been built up and tested in the bakehouse. The practical significance of the application of modern breeding principles in the improvement of the quality of wheat is further illustrated by the experiments of the Home Grown Committee

[9]Biffen, R. H. On the Inheritance of Strength in Wheat. Jour. Agr. Sci. 1908. V. III pp. 86-101.

of the National Association of British and Irish Millers[10] which demonstrated that a number of varieties, notably the Red Fife selections retain their original strength under all conditions when other varieties change enormously with climate and soil. Similar results were obtained by Howard, Leake and Howard[11] in India who found that among 25 pure line cultures representing as many distinct wheats, when grown under different conditions at three stations, some strains always remained soft, some had a tendency to remain hard while with the majority of these strains the consistancy varied greatly according to the locality and the conditions under which they are grown (L.c. p. 59). Four strong wheats and one soft strain were each grown at 9 different stations under widely varying conditions of climate, soil and culture. The 4 strains consistently retained their strength and milling qualities while the soft strain always remained a weak wheat.

As a further illustration of the effectiveness of the application of modern plant breeding methods in the improvement of wheat quality the results at the Central Experimental Farm at Ottawa, Ontario, those of Farrer in New South Wales, of Clark [12] and of Leith[13] should be cited.

The results of a recent investigation of Freeman[14] are of special interest in their bearing upon the influence of environment upon the texture of the wheat kernel. In his experiments involving crosses between soft wheats and durum, Freeman established two types of soft grains. One type was designated by him as "true softness" in which the air spaces in the endosperm are diffuse and finely scattered. This type of softness is only slightly affected by environic conditions. The second type, commonly called "yellow berry" was characterized by air spaces

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[10]Humphries, A. E. and Biffen, R. H. The Improvement of English Wheat. Jour. Agr. Sci. 1917, V. 2, pp. 1-16.

[11]Howard, Albert, Leake, H. M. and Howard, G. L. C. The Influence of the Environment on the Milling and Baking Qualities of Wheat in India. Memoirs Dept. Agr. India 1913. Vol. V. No. 2, pp. 45-102.

[12]Clark, J. A. Improvement of Ghirka Spring Wheat in Yield and Quality. 1916. U. S. Dept. Agric. Bu. Plant. Ind. Bull. 450, pp. 1-19.

[13]Leith, B. D. The milling and Baking Qualities of Wisconsin Grown Wheats. Wisc. Agr. Exp. Sta. Res. Bull. 43, 1919. pp. 1-38.

[14]Freeman, Geo. F. Producing Bread Making Wheats for Warm Climates. Jour. Heredity, 1918, V. 9, No. 5, pp. 211-226.

within the endosperm occurring in flakelike groups with quite definite margins, causing a more or less extending opaqueness. This type was found to be very sensitive to environic conditions. Both types were found to exhibit a distinctly different genetic behavior controlled by different sets of genetic factors. The practical importance of these results is apparent for they draw a distinct line between true soft wheats like Sonora, Early Bart which are not affected by climate and are every year 100% soft, and the hard wheats whose response to environmental influences manifests itself in a greater or less percentage of "yellow berries."

The present paper deals with the results obtained in the work with a number of pure lines of wheat originated and grown at the Aroostook Farm of the Maine Agricultural Experiment Station. The main object of this work was to attempt to improve the strength of the Aroostook wheats, and this bulletin may be regarded in a way as a progress report on that phase of this work based on the method of pure line selection. In presenting the results of the chemical analyses the writer wishes to emphasize the fact that these data reflecting as they do the chemical composition and behavior of the wheats and flours, all refer to pure strains of wheat in distinction to commercial varieties and flours. Some observations on the effect of the environmental conditions of Northern Maine upon a few pure strains of wheat introduced from Minnesota are also here reported.

CLIMATE AND SOIL RELATIONS IN AROOSTOOK COUNTY.

As already stated the growing of wheat in Maine is confined to its northern section made up chiefly of Aroostook County. In view of the exceptional significance commonly attached to the environment in relation to the quality of wheat, a brief consideration of the climatic and soil factors of Northern Maine appears desirable.

Northern Maine is characterized by a cool, and moist climate and a short growing season. The mean temperature, the rainfall, and the number of clear days for the five months in each of the last 7 seasons, 1913-1919, are given in Table 1.

The outstanding feature in this table is the high precipitation during the growing season. Reference to the data on cli-

matic conditions given by Carlton[15] for the principal wheat growing centres in Russia and in the United States shows that the total precipitation for the growing season at Presque Isle—16.05 inches—is considerably higher than at the principal wheat growing points of the Russian prairies and generally higher than at points in the Great Plains. While this alone would not constitute a specially detrimental feature in connection with the cultivation of wheat, a consideration of the peculiarities of the Aroostook growing season indicates that the distribution of the rainfall in the different months of the season may have some effect upon the quality of Aroostook grown wheat. The time of seeding small grains in Aroostook County extends usually

TABLE 1.

Temperature, Rainfall in Inches and Number of Clear Days for the 5 Growing Months of the Seasons 1913-1919. Recorded at Presque Isle, Aroostook County.

Month	Temperature Precipitation No. clear days	Year							
		1913	1914	1915	1916	1917	1918	1919	Average
May	Mean Temp.	48.60	53.19	49.50	50.82	43.13	51.00	50.50	49.46
	Precipitation	3.53	2.74	4.05	3.45	3.90	4.00	3.32	3.57
	No. clear days	15	18	10	12	8	17	11	13
June	Mean Temp.		56.03	60.60	59.65	59.84			59.03
	Precipitation	1.20	4.80	1.95	2.17	7.67		1.26	3.18
	No. clear days	18	12	12	10	10		15	13
July	Mean Temp.	69.30	63.55	64.10	65.00	67.95			65.98
	Precipitation	5.18	2.23	3.40	3.68	2.56		3.80	3.48
	No. clear days	9	24	18	17	15		14	16
August	Mean Temp.	61.40	60.17	61.80	71.90	66.90		61.00	63.86
	Precipitation	3.01	2.35	3.50	1.70	5.30		1.75	2.94
	No. clear days	20	22	15	11	18		11	16
September	Mean Temp.	53.20	55.80	56.45	58.92	53.05		53.60	55.17
	Precipitation	2.01	2.10	3.25	4.05	1.41		4.56	2.90
	No. clear days	19	19	19	15	19		13	17
Totals for growing season:									
Total Precipitation		14.93	14.22	16.15	15.05	20.84		14.69	16.05
Total No. clear days		81	95	74	65	70		64	75
Average mean temperature of growing season		58.10	57.75	58.49	61.26	58.18		55.00	58.70

[15]Carlton, M. A. The Small Grains, 1916, pp. 699. The MacMillan Co., New York.

from the 8-20 of May. Owing to the cool, moist conditions in Aroostook the vegetative period of wheat is rather extended and the flowering which begins about the middle of July continues to about the end of July. August is the ripening month, the wheat being harvested in the last week of August or the first week of September. Referring to the figures in the last column of Table 1 it will be seen that the highest precipitations occur in May, 3.57 inches, but that the rainfall during the period of ripening and harvest—August,—is only slightly over half an inch or 18 per cent less than the maximum monthly rainfall for the season. Rainy weather during the period of ripening and harvest not only may have a detrimental effect upon the appearance of grain but is associated with another feature of climate, namely humidity which is known to have a distinct effect upon the quality of wheat. High relative humidity associated with an overcast sky characterizes the weather in Aroostook County towards the end of July and the first week of August which period marks the first stages of the kernel formation. This feature is rather unfortunate as dry weather and a clear sky during the process of ripening are very essential to the production of a strong, high grade wheat. This humid condition protracts the ripening period and delays the harvest. The lengthened ripening period extending through August results in a further drawback as the formation of the wheat kernel does not coincide under Aroostook conditions with the highest seasonal temperature, which marks the month of July. While from the seven year average given in Table 1 it appears that the mean temperature in August is only 2 degrees lower than in July, the actual difference is much greater since the amount of sunlight and heat decreases in the shortening days of August. Medium late wheat varieties when planted in the latter part of May often do not mature until the first week of September when frequently the first early frosts occur.

While these are the natural limitations relative to the growing of strong wheat in Aroostook, it must be admitted that the climatic conditions prevailing there are favorable in regard to other features of the wheat crop. Thus the wheat crop is practically free from insect pests, and is seldom affected with stem rust.

SOILS.

The soils of Aroostook County have been formed by glacial drift, and vary from sand to heavy silt loams. According to Westover and Rowe[16] there are twelve distinct soil types in Aroostook County, but the greater part of the area is made up of a friable loam, Caribou loam, derived from unmodified glacial drift. The Caribou loam is composed of about 50% silt and only 16% of clay, the rest being made up of more or less fine sand and gravel. The soil though most ideal for the potato crop, is well adapted to small grains. The average yield of wheat is about 25 bushels per acre. The fertility of the soil is kept up by high applications of commercial fertilizers in connection with the potato crop, very little barnyard manure being used. The humus content of Aroostook soils is restored through cultural methods which consist of a crop rotation usually including potatoes one year, grain one year and clover and timothy for two or three years. Frequently, however, this rotation is not adhered to potatoes being grown for two or more years in succession. In such cases the drain upon the humus of the soil is probably too great to insure good wheat crops following the potatoes.

CHARACTERISTICS OF THE AROOSTOOK GROWN WHEATS.

The commercial wheat varieties grown in Aroostook are classed with the semi-hard spring wheats of the Northeastern wheat district. The varieties of wheat grown at present in Aroostook belong to two spring wheat groups—Fife and Preston. Owing to the prejudice of some growers against the awned wheat, the majority of the Aroostook wheat varieties belong to the beardless Fife group. More recently the Marquis wheat has found its way from the Northwest into Aroostook County, but does not seem to be so well adapted as the Fife wheats.

An investigation into the physical characteristics and chemical composition of Aroostook grown wheats and into their mill-

[16]H. L. Westover and R. W. Rowe. Soil Survey of the Caribou Area, Maine, U. S. Dept. Agr. Bur. of Soils, 1910, pp. 1-40.

ing and baking value was made by Woods and Merrill[17]. An especially interesting feature of their investigation in its bearing upon the observations reported in the present paper is their study on the effect of the climate upon the physical appearance and chemical composition of wheats imported from the Northwest and grown in Aroostook. They found that the wheat varieties introduced from the Northwest changed their physical and chemical character at the end of a single season, the change being most pronounced in the increased size of the kernel. Relative to the effect of Aroostook environmental conditions upon the protein content of Northwestern wheats the evidence from the trials of Woods and Merrill is inconclusive. In the first experiment one of the three varieties tested, Lamona wheat, suffered at the end of the first season under Aroostook conditions a large loss of nitrogen and a still larger loss in the gluten content, while the Fife wheat showed only a small decrease in gluten and the Bluestem wheat made a slight gain in protein, both these varieties gaining in gluten. The results from the second experiment in which two pure strains of Minnesota bred Bluestem and one commercial variety of Bluestem were used, showed a decrease in protein content for the commercial variety and for one of the pure strains as compared with the Minnesota grown parents, but on the following year all three varieties showed a higher percentage of protein in the Aroostook grown progeny than in the check trials of the Minnesota grown progeny.

As to the baking quality of the Aroostook grown wheats the baking tests reported by Woods and Merrill show that the flour from Maine wheats produced as a rule loaves of smaller volume than the Minnesota standard flour, though of good quality. The writers noting the arbitrary nature of the northwestern standard, suggest that Maine develop the growing and milling of wheat along its own lines, and express the belief that "by careful breeding from wheat now being grown in Maine it would be possible to develop a strain equal for Maine conditions to some of the improved strains of other sections."

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[17]Chas. D. Woods and L. H. Merrill. Notes and Experiments upon the Wheats and Flours of Aroostook County. Maine Agr. Expt. Sta. Ann. Rept. 1903, pp. 145-180. (Bull. No. 97).

MATERIAL AND METHODS.

In undertaking the wheat improvement work at Aroostook Farm in 1915 the question arose as to what material should be used as the source of improved wheat strains. A consideration of the deterioration in the physical characteristics of the northwestern wheats under Aroostook conditions, and of the great differences between the environment of Maine and the Northwest, at once suggested the advisability of confining the selection work chiefly to the native Aroostook grown wheats or adjoining regions. Since the quality of the wheat crop appears quite susceptible to the influence of climatic factors it was thought that the reaction, if any, of the different varieties and strains in the course of many seasons to the environmental factors has long become established in the form of a greater or less degree of adaptation. Selection work on these varieties would result in the isolation of the best adapted varieties or strains and in the elimination of the poorly adapted ones, the degree of adaptation being measured by the maximum quality of any given strain.

The methods used in the wheat improvement work at Aroostook are based on the principles of pure line selection and hybridization. The present paper deals only with the results of the selection work. For a detailed account of the method of pure line selection and of the field technic as applied to small grains by this Station the reader may be referred to a previous paper.[18] We may only consider here a few features not mentioned in the paper just cited, which are peculiar to wheat. In selecting wheat strains for quality a certain procedure of diagnostic value is required by means of which the relative quality of the different individual plants may be determined. The yield of grain from a single spike is obviously too small to be used for a nitrogen analysis or even for a gluten determination by the chewing test without interfering with the propagation of the seed. The estimation of the quality of the grain from the individual spikes following their isolation from commercial varieties was based in this work upon the hardness, color, size and

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[18]Frank M. Surface and Jacob Zinn. Studies on Oat Breeding IV. Pure Line Varieties. Maine Agric. Exp. Station, Ann. Rept. 1916, pp. 97-148 (Bulletin No. 250).

texture of the kernel. While it is recognized that these features are not always a reliable index of the quality of wheat, especially when estimating grains from different varieties, yet the diagnostic value of these determinations is enhanced when they are made upon different strains within the same variety. The determination of the physical characters of a number of strains within the same variety soon leads to the formation of a standard for each variety so that the relative quality of the kernels from the strains of the same variety can be fairly accurately judged. It may be added in this connection that the determination of the characters of the grain at the early stage of selection is really of no great importance since it is the progeny of the selected plants, the first generation after selection, that offers a more reliable basis for the determination of quality.

BRIEF ACCOUNT OF THE ORIGIN OF THE PURE LINES OF WHEAT AT AROOSTOOK FARM.

In 1915 several hundred selections were made from commercial varieties of wheat grown at Aroostook Farm and from a number of wheat fields in the County. In this work normal, medium sized spikes well developed at the tip, were selected rather than whole plants since in the close field stand it is not always possible with certainty to isolate individual plants. In these selections were represented wheat spikes of the four groups of spring wheat: Fife, Bluestem, Preston and Durum. Representative spikes and grain of these wheats are shown in Figures 1 to 6. Of these selections 259 spikes were retained and planted in rows in the cereal crop nursery in 1916. Each row was planted with the seed of a single wheat spike. The number of rows grown in 1916, each representing a strain selected from the different varieties is given on page 17.

During the growing season notes were taken on the characters of the spikes, tillering capacity, strength of straw, susceptibility to disease as well as data relative to time of heading and bloom. The data on the physical characters of the grain in conjunction with the field notes served as a basis for further selection as a result of which 91 strains of the original 259 were retained. These 91 strains were planted in 1917 in one two-thousandth acre plots. Along with the pure lines of Aroostook

FIGURE 1.

FIGURE 2.

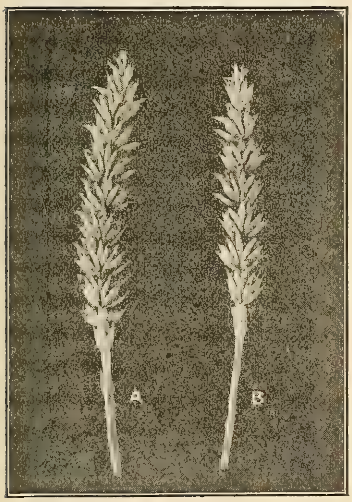


FIGURE 3.

FIGURE 4.

FIG. 1.—Representing heads of two groups of spring wheat: A, Red Fife (Line No. 2393); B, Bluestem (Line No. 2387).

FIG. 2.—Heads representing two spring wheat varieties: A, Marquis (Line No. 2398); B, Preston (Line No. 2388).

FIG. 3.—A, Royalton Red, Accession No. 186; B, Royalton White, Accession No. 185.

FIG. 4.—Head of Durum wheat (Speltz Marz, Accession No. 182.)

Variety	No. of Garden Rows in 1916	No. of Strains Continued in 1917
Red Fife	41	15
Preston	37	17
Bluestem	25	20
Marquis	49	12
Canada Red*	32	19
Unnamed	70	8
Durum	5	—
Total	259	91

grown wheats there were also tested in one two-thousandth acre plots 7 pure strains of hard spring wheat which had been obtained from Minnesota in the winter of 1916. The writer wishes to express his appreciation of the courtesy of Prof. H. K. Hayes of the University of Minnesota in sending these wheats to him. The Minnesota strains included one representative of each of the following varieties: Bluestem (Haynes Bluestem), Marquis, Velvet Chaff, Royalton (Red), Royalton (White) and two representatives of durum wheat, Speltz Marz (Fig. 4) and Hedge Row. According to a written communication from Professor Hayes the Royalton wheat was originally obtained from Royalton, Minn., and its origin was possibly a natural cross. The two strains of this wheat are very distinct, one (Royalton White) possessing a smooth chaffed spike and white grain suggestive of the White Fife, while the other strain (Royalton Red) produces a red grain and a hairy chaffed spike similar to Bluestem. The spikes of these two strains are reproduced in Fig. 3. All the Minnesota strains have been given Maine accession numbers 182 to 187.

The crop from the one two-thousandth acre plots in 1917 furnished enough seed from each strain to make a chemical analysis of the crude protein content. A further scrutiny of these pure lines on the basis of the chemical analysis and the field notes resulted in the discarding of a number of strains until 44 pure lines of Aroostook wheats and 6 pure lines of

*Dr. Chas. E. Saunders, Cerealist at the Central Experimental Farm at Ottawa, informs me that the variety here listed under the name Canada Red is probably the variety called Black Sea (identical with Ladoga). It is a bearded wheat, with smooth, reddish brown chaff and producing red kernels.

Minnesota wheats were retained. These were grown in the season of 1918 in plots ranging from one two-hundredth to one-fortieth acre in area. A further selection in the fall of 1918 reduced the number of strains to 26 originally selected from Aroostook wheats and to 5 Minnesota lines. A complete chemical analysis of 37 lines and baking tests of 31 wheat lines were made in the spring of 1919. Using the baking test as the final index of strength, out of the 31 tested strains 12 Aroostook lines and 4 Minnesota lines were retained and propagated in 1919 in one-twentieth acre plots.

ANALYSIS OF DATA.

PHYSICAL CHARACTERISTICS OF THE GRAIN.

The most striking feature in the physical appearance of the grain from the Aroostook grown lines is the size and weight of the kernels. Their size is larger than that of spring wheat of the Northwest and their plump, well rounded shape, distinguishes them from the wheats of the prairie regions. The size and shape relations of the grain of the Aroostook pure lines are illustrated in Figures 5 and 6, which represent kernels of four pure lines each belonging to a distinct wheat variety. As a result of these size and shape relations the weight of the kernels is correspondingly high. In Table 2 is given the weight per 1000 kernels of each of the pure lines grown in 1918. The lines are grouped according to the variety from which they originated and their rank in respect to kernel weight.

It may be well to point out that the determination of the kernel weight based on 1000 kernels expresses very exact relations repeated determinations showing the experimental error to be either negligible or nil. Therefore, the differences in the 1000-kernel-weight of these lines are more significant than they might appear at first sight. From Table 2 it will be noted that the average weight per 1000 kernels for all lines is quite high—35.314 grams. The average weights per 1000 kernels for the varieties do not show great differences though they very well reflect varietal means around which the strains within the varieties are grouped. The individual strains show a considerable deviation from the average of the varieties from

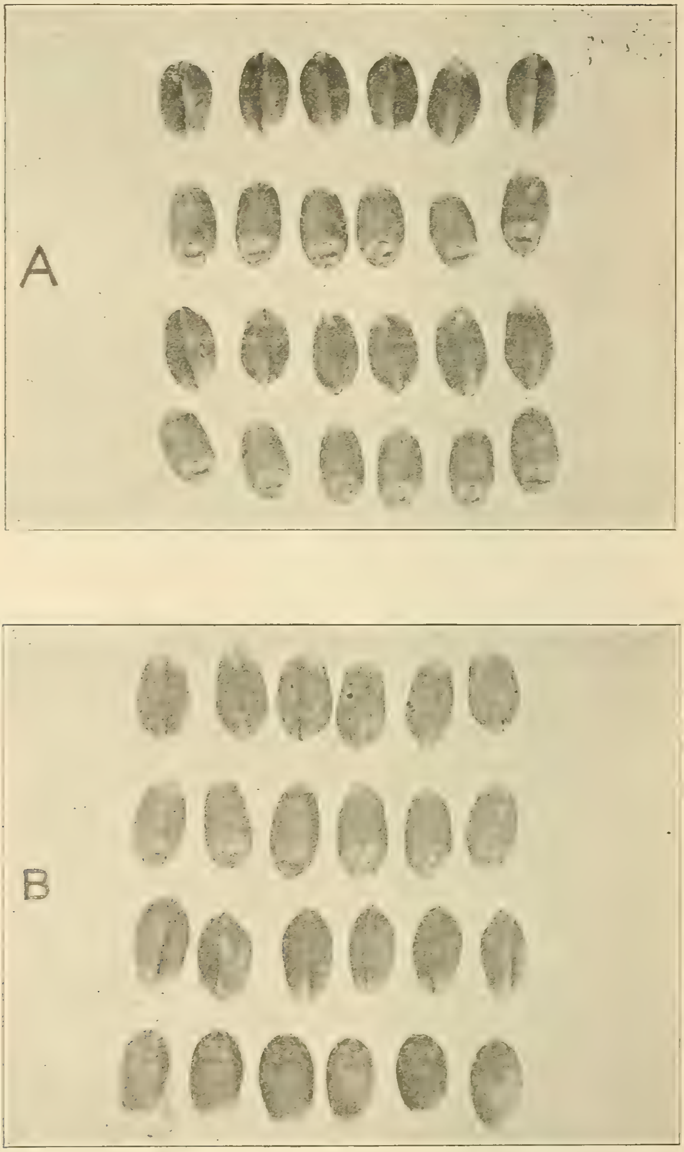
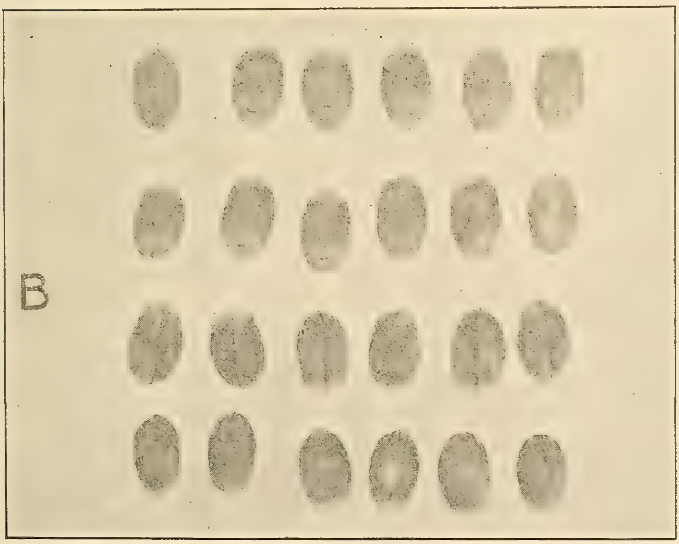


FIG. 5.—Kernels of two pure lines of wheat: A, Line No. 2389 (Red Fife); B, Line No. 2384 (Bluestem).

A



B

FIG. 6.—Kernels of two pure lines of wheat: A, Line No. 2388 (Preston); B, Line No. 2398 (Marquis).

TABLE 2.

Weight per 1000 Kernels of each Pure Line.

AROOSTOOK LINES

Line No.	Selected from Variety	Weight in grams
2389	Red Fife	31.180
2385	Red Fife	34.093
2379	Red Fife	34.344
2386	Red Fife	34.358
2395	Red Fife	34.536
2390	Red Fife	34.637
2393	Red Fife	34.882
Average		34.004
2394	Bluestem	34.160
2391	Bluestem	35.102
2384	Bluestem	36.043
2387	Bluestem	37.460
Average		35.691
2383	Preston	26.541
2397	Preston	30.186
2388	Preston	32.535
2414	Preston	33.556
2402	Preston	39.093
2405	Preston	43.890
2409	Preston	44.032
2400	Preston	44.789
Average		36.828
2410	Marquis	33.174
2398	Marquis	34.055
Average		33.611
2373	Canada Red	30.186
2396	Canada Red	34.498
Average		32.337
2370	Unnamed	35.942
2415	Unnamed	37.341
2406	Unnamed	37.574
Average		36.952

Average for all Aroostook lines: 35.314

which they originated as well as from the average for all lines. Thus the Preston Line 2383 has a 1000-kernel-weight over 10 grams lower than the average for the variety and over 18 grams lower than the highest weight in this variety, —44.789 grams of Line 2400. This line exceeds the average for the variety by nearly 8 grams. With the exception of Line No. 2389 the Red Fife lines show a remarkable uniformity in the 1000 kernel weight with an average below that for all lines. The Bluestem strains rank higher with an average equal to that for all lines,

while the Preston lines, with the exception of the few strains of the Unnamed variety, rank highest. The great variations in the 1000-kernel-weight of the individual strains grown in the same season on a limited, uniform piece of land, are rather noteworthy. It is further of interest to note that the lines with the very high weight per 1000 kernels as a rule yielded flour of poor baking quality. The lines that produced the largest bread volume were those with a 1000-kernel-weight not over 35 grams.

Table 3 shows the remarkable effect exerted by the Aroostook environment upon the weight of kernels of the Minnesota lines.

TABLE 3.

Showing Effect of Aroostook Growing Conditions Upon the Weight of Kernel of Pure Lines Introduced from Minnesota.

Maine Accession No.	Minnesota Accession No.	N. S. N.	Selected from Variety	Weight in grams per 1000 kernels: of original seed grown in Minnesota	Weight in grams per 1000 kernels: of the same seed grown one season in Aroostook
183	1011	I-15-161	Velvet Chaff	19.786	32.891
186	1037	I-12-1	Royalton (Red)	22.000	34.315
185	1037	I-12-6	Royalton (White)	20.923	35.105
181	188x188	II-06-39	Preston x Preston	22.268	37.241
184	470	I-06-52	Hedge Row (durum)	37.411	43.104
182	337	I-00-45	Speltz Marz (durum)	37.386	45.510
Average				26.629	38.028
Average (excluding the durum lines)				21.244	34.888

The average weight per 1000 kernels of the original seed has increased by 18.7 per cent in the course of one season. It should, however, be stated that at the time of the determination of the 1000-kernel-weight the original Minnesota grown seed was older and therefore drier than the Aroostook grown seed and considerably shriveled, so that the actual difference in weight should probably be smaller. On comparing the data in Table 3 with those in Table 2 it will be seen that the average weight per 1000 kernels of the Aroostook lines is practically identical with the average weight of the Minnesota lines attained under Aroostook conditions. These data which very well agree with

the observations of Woods and Merrill[19] on 2 races of Minnesota wheat are too meager to draw from them general conclusions. The evidence obtained from the examined number of pure lines indicates that the environmental factors prevailing in Aroostook brought the kernel weight of the original Minnesota strains up to the level of the Aroostook strains very rapidly, in fact, within a single season. Further determinations made on the grain of the crop of 1918 indicate that this change in the kernel weight of the Minnesota lines is not progressive.

In regard to other physical characteristics as color, texture and hardness it was found that there was some variation among the different lines, but only of a comparatively slight nature since these characteristics were primarily used as a basis for selection. As a rule the strains with the highest weight per 1000 kernels showed the least degree of flintiness and the highest percentage of "yellow berry".

Of the Minnesota wheats 4 strains Royalton (Red), Royalton (White) Haynes Bluestem and Marquis, respectively, while suffering some loss in flintiness as compared with their original condition in Minnesota, appeared to be of good color, and texture; of the remaining three Minnesota strains the Velvet Chaff strain showed a tendency towards developing "yellow berries" while the two durum lines showed a most striking degree of deterioration. The original Minnesota sample of these lines exhibited all the characteristics of the corneous transclucent grains of the Northwestern durum wheats; after one season's growth under Aroostook conditions the already large grain gained from 6 to 8 grams per 1000 kernels and showed a very large percentage of opaque kernels of either partly or wholly starchy texture. This rapid change of the durum strains grown side by side with a number of other lines retaining their hard texture and good color furnished the best illustration of the difference in the degree of adaptation and response to the environment of the different wheat varieties. The effect of the Aroostook environment upon the size and shape of the original Minnesota seed is illustrated in Figures 7 and 8.

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[19]Loc. cit.

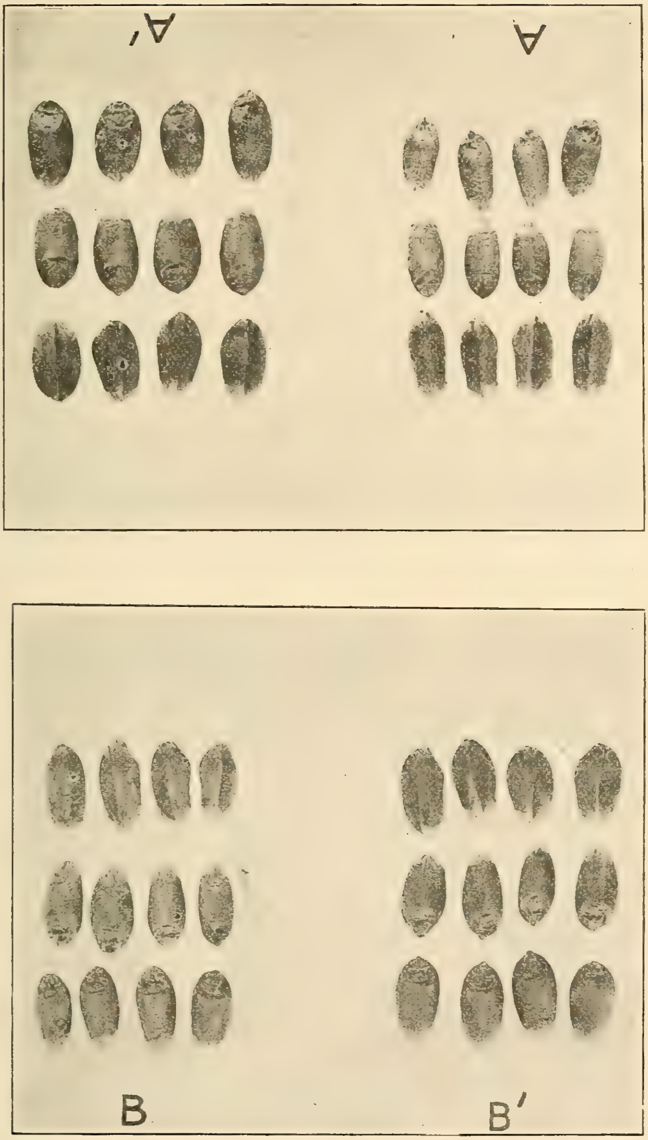

FIG. 7.—Showing effect of Aroostook environmental conditions upon the size and shape of wheat introduced from Minnesota: A and B, original, Minnesota grown seed (Royalton Red and Royalton White, respectively); A' and B' same seed after one esason's growth at Aroostook Farm.

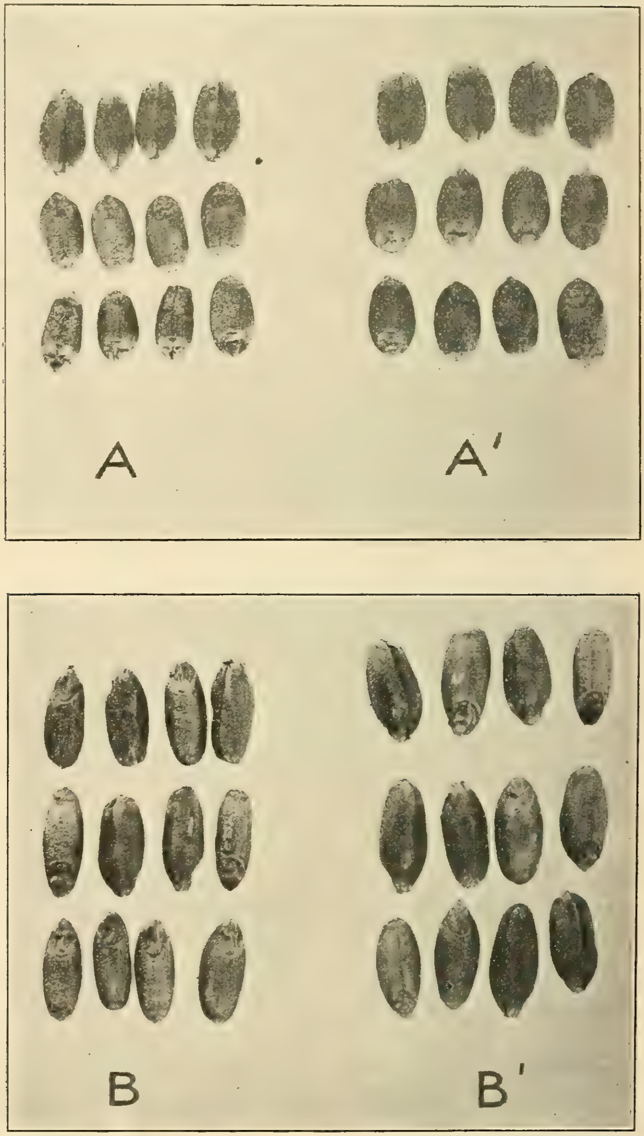

FIG. 8.—Showing effect of Aroostook environmental conditions upon the size and shape of wheat introduced from Minnesota: A and B, original, Minnesota grown seed (Marquis and Durum, respectively); A′ and B′ same seed after one season's growth at Aroostook Farm.

YIELD OF THE PURE LINES IN 1918.

As already stated the pure lines were propagated in 1918 in plots ranging according to the available seed from one two-hundredth to one-fortieth acre in area. The season of 1918 was typical of Aroostook conditions, marked by heavy rain-storms which lodged some of the wheat thus offering an opportunity of

TABLE 4.

Yield and Weight per Measured Bushel of Pure Lines Grown in 1918.

AROOSTOOK LINES.

Line No.	Selected from Variety	Plot No.	Yield of Grain		Weight per measured bushel in lbs.
			Pounds per plot	Bushels per acre	
2385	Red Fife	870	5.13	51.58	60.5
2395	Red Fife	882	12.69	39.88	61.5
2393	Red Fife	880	11.44	38.62	61.3
2386	Red Fife	871	12.25	37.73	62.0
2379	Red Fife	864	4.50	33.72	
2389	Red Fife	875	10.00	33.51	61.0
2390	Red Fife	876	8.06	26.15	60.5
2387	Bluestem	873	11.88	48.00	60.0
2404	Bluestem	890	10.69	34.66	
2384	Bluestem	869	10.81	38.92	60.5
2394	Bluestem	881	11.00	34.54	60.0
2391	Bluestem	877	10.31	33.44	60.5
2382	Bluestem	867	3.00	23.93	
2402	Preston	893	3.50	53.79	
2414	Preston	910	39.75	40.04	62.5
2405	Preston	891	13.34	39.26	60.5
2400	Preston	907	40.00	34.62	62.0
2409	Preston	900	20.88	32.48	62.0
2397	Preston	884	7.75	31.79	63.3
2388	Preston	874	9.00	31.10	63.0
2381	Preston	866	4.34	29.25	
2380	Preston	865	1.65	28.62	
2383	Preston	868	5.25	25.20	61.5
2411	Preston	902	14.00	25.41	59.8
2408	Preston	894	7.13	23.71	
2398	Marquis	885	10.38	35.27	61.3
2410	Marquis	895	11.50	25.73	62.0
2378	Canada Red	909	17.00	42.74	
2375	Canada Red	904	24.00	39.35	
2376	Canada Red	905	20.00	38.54	
2374	Canada Red	901	22.75	36.47	
2372	Canada Red	898	22.00	36.68	
2371	Canada Red	896	21.75	35.73	
2373	Canada Red	899	21.50	35.04	57.5
2396	Canada Red	883	8.81	33.80	62.0
2406	Unnamed	892	13.94	44.49	57.5
2415	Unnamed	911	31.00	43.55	60.0
2370	Unnamed	862	4.75	37.54	60.5

Yield and Weight per Measured Bushel of Pure Lines Grown in 1918.—Concluded.

MINNESOTA LINES.

Maine Access. No.	Minnesota Access. No.	Selected from Variety	Plot No.	Yield of Grain		Weight per measured bushel in lbs.
				Pounds per plot	Bushels per acre	
187	1239	Marquis	888	6.56	35.81	60.5
182	337	Speltz Marz (durum)	878	11.25	34.62	64.5
183	1011	Velvet Chaff	889	10.25	34.29	60.5
186	1037	Royalton (Red)	872	10.00	34.17	60.8
189	169	Haynes Bluestem	879	11.00	33.85	59.8
185	1037	Royalton (White)	897	13.13	32.59	60.5

judging the relative strength of straw of the different lines. The smaller plots were cut by hand with the sickle or cradle, the larger ones were reaped with the binder. The threshing was done according to the size of the plots, either with the small threshing machine used in threshing experimental plots up to one-eightieth acre in area, or with the large, farm threshing machine. The yields of 44 pure lines and the bushel weight of most of them are given in Table 4.

While relatively considered, these plots are of different size and absolutely taken, quite small, there were enough plots of approximatly the same area to give some idea of the behavior of these lines as to yield. An inspection of Table 4 will show a considerable variation in the yield of the different lines. Every variety contains strains of high and low yielding capacity. In the cases where a larger yield was obtained from an equal or smaller area the differences in yield are probably significant. Considering the larger plots in which the Canada Red strains grew, this variety furnished a number of high yielding lines. Some of the Preston lines yielded well, as did some of the Red Fife and Bluestem lines. The Minnesota lines very well approached the yielding capacity of the Aroostook lines.

From Table 4 it will be noted that these lines test rather high and that there is little variation in the bushel weight. Only two of the 44 lines tested appreciably below the standard weight, the great majority exceeding it by 0.5 to 3 pounds, and in one case (durum) by 4.5 pounds. The Preston lines stand out rather prominently with their higher bushel weight, and it is of interest

to note that line 2388 showing the highest bushel weight of all Aroostook lines furnished a flour of very good quality, best of all Preston lines. The Minnesota lines, with the exception of durum, are well grouped about the standard weight.

CHEMICAL CHARACTERS OF THE PURE LINES.

PROTEIN ANALYSIS IN 1917.

The protein content of the pure lines was first determined in 1917.* In computing the protein content from the nitrogen the factor 5.7 was used. The results of the analysis of 99 pure lines are given in Table 5. The lines are grouped within the varieties from which they originated, and according to their nitrogen rank.

An inspection of Table 5 shows a relatively high average percentage of protein for the different varieties. Certain lines within each variety group possess a protein content which under Aroostook conditions must be regarded as decidedly high. This should not surprise one if it is recalled that the lines were selected for high nitrogen as indicated by their physical characteristics. From Table 5 it will be noted that the Canada Red variety shows the highest average protein content —14.31 per cent—of all Aroostook lines. This group is followed by the Preston, Bluestem, Red Fife, Unnamed and Marquis varieties in the order named. The Minnesota lines, excluding the durum wheats which proved to be least adapted to Aroostok conditions and should be treated separately by themselves, show an average crude protein content practically equal to that of Canada Red. The average protein content of all Aroostook lines taken together is 13.81 per cent while the Minnesota lines with an average of 14.36 show a hardly significant difference of about 0.5 per cent.

It will be of interest to compare the protein content of the Minnesota lines originally grown in Minnesota with that of their progeny grown one season in Aroostook. In Table 6 are tabulated the data on the protein content of the original Minnesota grown seed and of the Aroostook grown progeny.

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*Credit is due to the Chemistry Department of this Station for the chemical analyses of wheat of the pure lines in 1917 and 1918.

TABLE 5.

Crude Protein Content of Pure Lines of Wheat Grown at Aroostook Farm in 1917.

AROOSTOOK LINES

Line No.	Selected from Variety	Plot No.	Nitrogen	Crude Protein (N x 5.7) Per cent
2390	Red Fife	564	2.62	14.93
2429	Red Fife	557	2.50	14.25
2379	Red Fife	553	2.46	14.02
2461	Red Fife	566	2.45	13.97
2389	Red Fife	555	2.44	13 91
2393	Red Fife	558	2.44	13.91
2422	Red Fife	551	2.42	13.79
2386	Red Fife	556	2.40	13.68
2395	Red Fife	559	2.39	13.62
2434	Red Fife	560	2.34	13.34
2436	Red Fife	561	2.34	13.34
2423	Red Fife	552	2.33	13.20
2444	Red Fife	563	2.30	13.11
2385	Red Fife	565	2.28	13.00
2439	Red Fife	562	2.24	12.77
Average			2.40	13.68
2384	Bluestem	592	2.63	14.99
2635	Bluestem	646	2.59	14.76
2387	Bluestem	594	2.52	14.36
2394	Bluestem	642	2.51	14.31
2382	Bluestem	597	2.50	14.25
2404	Bluestem	645	2.48	14.14
2510	Bluestem	591	2.47	14.08
2506	Bluestem	589	2.44	13.91
2507	Bluestem	590	2.43	13.85
2514	Bluestem	593	2.41	13.74
2412	Bluestem	596	2.40	13.68
2391	Bluestem	644	2.39	13.62
2521	Bluestem	599	2.39	13.62
2520	Bluestem	598	2.38	13.57
2516	Bluestem	595	2.37	13.51
2503	Bluestem	587	2.34	13.34
2505	Bluestem	588	2.31	13.17
2502	Bluestem	586	2.30	13.11
2501	Bluestem	585	2.28	13.00
2500	Bluestem	584	2.07	11.81
Average			**2.41**	**13.74**
2408	Preston	579	2.66	15.16
2402	Preston	575	2.63	14.99
2381	Preston	637	2.54	14.48
2397	Preston	638	2.52	14.36
2411	Preston	581	2.52	14.36
2388	Preston	571	2.52	14.36
2400	Preston	576	2.48	14.14
2383	Preston	578	2.46	14.02
2414	Preston	569	2.44	13.91
2477	Preston	572	2.42	13.79
2495	Preston	583	2.38	13.57
2409	Preston	577	2.36	13.45
2405	Preston	574	2.36	13.45
2470	Preston	568	2.36	13.45
2494	Preston	580	2.35	13.40
2498	Preston	582	2.33	13.21
2380	Preston	570	2.26	12.88

Crude Protein Content of Pure Lines of Wheat Grown at Aroostook Farm in 1917.—Concluded.

Line No.	Selected from Variety	Plot No.	Nitrogen	Crude Protein (N x 5.7) Per cent
Average			2.45	13.94
2410	Marquis	620	2.58	14.71
2556	Marquis	622	2.45	13.97
2555	Marquis	621	2.41	13.74
2587	Marquis	630	2.36	13.45
2583	Marquis	629	2.34	13.34
2401	Marquis	632	2.30	13.11
2398	Marquis	624	2.29	13.05
2558	Marquis	623	2.29	13.05
2561	Marquis	625	2.26	12.88
2588	Marquis	631	2.26	12.88
2579	Marquis	628	2.24	12.77
2569	Marquis	627	2.20	12.54
Average			2.33	13.29
2374	Canada Red	612	2.76	15.73
2377	Canada Red	613	2.64	15.05
2378	Canada Red	609	2.62	14.93
2373	Canada Red	604	2.61	14.88
2376	Canada Red	608	2.61	14.88
2372	Canada Red	605	2.61	14.88
2375	Canada Red	614	2.58	14.71
2544	Canada Red	618	2.56	14.59
2371	Canada Red	619	2.54	14.48
2543	Canada Red	617	2.50	14.25
2535	Canada Red	610	2.50	14.25
2531	Canada Red	607	2.46	14.02
2529	Canada Red	606	2.44	13.91
2523	Canada Red	601	2.42	13.79
2524	Canada Red	602	2.40	13.68
2522	Canada Red	600	2.38	13.57
2525	Canada Red	603	2.26	12.88
2536	Canada Red	611	2.24	12.77
Average			2.51	14.30
2370	Unnamed	616	2.59	14.76
2415	Unnamed	640	2.52	14.36
2607	Unnamed	641	2.50	14.25
2479	Unnamed	633	2.48	14.14
2406	Unnamed	639	2.38	13.57
2597	Unnamed	636	2.33	13.28
2592	Unnamed	635	2.32	13.22
2465	Unnamed	634	2.28	13.00
2396	Unnamed	567	2.27	12.94
Average			2.40	13.69

MINNESOTA LINES.

Maine Access. No.	Minnesota Accession No.	N. S. N.	Selected from Variety	Plot No.	Nitrogen	Crude Protein (N x 5.7)
183	1011	I-15-161	Velvet Chaff	654	2.71	15.45
180	169	I-16-19	Haynes Bluestem	648	2.52	14.36
186	1037	I-12-1	Royalton (Red)	651	2.48	14.14
185	1037	I-12-6	Royalton (White)	647	2.48	14.14
181	188x188	II-06-39	Preston x Preston	652	2.47	14.08
187	1239	I-16-81	Marquis	650	2.46	14.02
182	337	I-00-45	Speltz Marz (durum)	653	2.18	12.43
184	470	I-00-52	Hedge Row (durum)	649	2.04	11.59
Average					2.42	13.79
Average for Minnesota Lines (exclusive of durum lines)					2.52	14.36
Average for Aroostook Lines					2.43	13.81

A comparison of the two sets of data given in Table 6 shows that the Minnesota lines when transferred into Aroostook and grown there one season suffered a loss of only about 0.8 per cent of protein. If we further add that the original Minnesota grown seed, when analyzed for protein was considerably older, and having a lower moisture content than the Aroostook progeny grown from it, the latter's loss of 0.8 per cent of protein as compared with the former becomes negligible.

TABLE 6.

Comparison of the Protein Content of the Minnesota Grown Lines with that of their Aroostook Grown Progeny.

Maine Access. No.	Minnesota Accession No.	N. S. N.	Selected from Variety	Original Minnesota grown seed: Nitrogen in per cent	Original Minnesota grown seed: Protein (Nx5.7) in per cent	Aroostook grown progeny: Nitrogen in per cent	Aroostook grown progeny: Protein (Nx5.7) in per cent
182	337	I-00-45	Speltz Marz (durum)	2.75	15.68	2.18	12.43
186	1037	I-12-1	Royalton (Red)	2.72	15.50	2.48	14.14
183	1011	I-15-161	Velvet Chaff	2.71	15.45	2.71	15.45
184	470	I-00-52	Hedge Row (durum)	2.68	15.28	2.04	11.59
185	1037	I-12-6	Royalton (White)	2.55	14.54	2.48	14.14
Average				2.68	15.30	2.42	13.79
Average (excluding durum lines)				2.66	15.17	2.52	14.36

A consideration of the changes caused by the Aroostook environment in the weight, size, shape of kernel as well as in the protein content of the original Minnesota grown seed very clearly indicates that the effect of the Aroostook environment upon the Minnesota grown wheats is decidedly more noticeable in the physical characteristics than in the crude protein content. A very notable exception are the two durum lines. The Minnesota grown Speltz Marz heads the list of the Minnesota lines in regard to protein content; at the end of one season's growth in Aroostook this line shows the second lowest protein content of all 99 lines analyzed. The second durum line, Hedge Row, suffered an even greater loss in nitrogen —3.69 per cent. By contrast, the Aroostook grown Velvet Chaff line shows a protein content identical with that of the Minnesota grown seed, while

Royalton (White) and Royalton (Red) suffered only a loss of 0.40 and 1.36 per cent, respectively. The grain of the durum lines showed also the most marked deterioration in the physical characteristics. This tendency of the durum wheats to rapidly deteriorate under Aroostook conditions was also borne out by the results from the 1918 crop which will be considered below.

A comparison of the average protein content of the Aroostook wheat lines with the average protein content of the chief classes of American wheats as given by L. M. Thomas[20] is of interest. In his extensive investigations made in the Office of Grain Standardization and involving several hundreds of samples, Thomas found the average crude protein content of the soft red winter, durum, hard red winter, and hard red spring wheats to be: 10.6, 14.3, 12.1, 12.9 per cent, respectively. The average crude protein content of the Aroostook pure lines of wheat grown in 1917 was found to be 13.81 per cent or nearly 1 per cent higher than the average for the class of hard red spring wheats as given by Thomas.

Chemical Analysis of The Pure Lines Grown in 1918.

At the stage of propagation of the pure lines reached with the harvest of the 1918 crop there was enough seed to make a complete chemical analysis and baking tests of these wheats. Of the 99 lines grown in 1917 only 44 were continued in 1918 and of these 40 were subjected to a chemical analysis. This reduction was due to the elimination of strains lacking in protein or in strength of straw and other desirable physical characteristics. The results of the chemical analysis of the 40 lines are presented in Table 7. The lines within each variety are grouped according to their protein content.

A study of the data in Table 7 will reveal first a general lowering of the average protein content of the pure lines as compared with the protein content of the 1917 crop. The variation in the average protein content ranges from 11.76 to 13.30 per cent as against 13.29 to 14.36 per cent for the 1917 crop when

[20]Thomas, L. M. A Comparison of Several Classes of American Wheats and a Consideration of Some Factors Influencing Quality. U. S. Dept. Agr. Bu. of Plant Ind. and Bu. of Markets 1917, Bul. 557, pp. 1-28.

the range of variation was somewhat narrower than in 1918. The growing conditions of the 1918 season had admittedly a levelling down effect upon the protein content of the pure lines. Apart from the seasonal influences there were other factors in

TABLE 7.

Chemical Composition of Pure Lines of Wheat Grown at Aroostook Farm in 1918.

AROOSTOOK LINES.

Line No.	Selected from Variety	Plot No.	Moisture	Ash	Nitrogen	Protein (Nx5.7)	Fat	Crude Fiber
2385	Red Fife	870	7.13	1.92	2.55	14.54	2.64	2.18
2390	Red Fife	876	7.98	2.05	2.42	13.79	2.42	2.49
2389	Red Fife	875	8.63	2.04	2.25	12.83	2.54	2.04
2393	Red Fife	880	9.88	1.98	2.14	12.20	2.01	2.10
2379	Red Fife	864	8.51	2.03	2.14	12.20	2.57	2.19
2386	Red Fife	871	9.65	1.95	2.13	12.14	2.24	2.19
2395	Red Fife	882	9.17	1.92	2.06	11.14	2.61	2.09
Average			8.71	1.98	2.24	12.77	2.47	2.18
2404	Bluestem	890	7.28	2.07	2.36	13.45	2.67	2.25
2391	Bluestem	877	7.52	2.01	2.34	13.34	2.38	2.26
2394	Bluestem	881	7.17	2.07	2.22	12.65	2.57	2.27
2387	Bluestem	873	8.74	2.16	2.19	12.48	2.56	2.20
2384	Bluestem	869	9.95	2.01	2.09	11.91	2.30	2.18
Average			8.08	2.06	2.24	12.77	2.50	2.23
2381	Preston	866	7.88	2.15	2.54	14.48	2.95	2.19
2402	Preston	893	8.71	2.12	2.42	13.79	2.54	2.36
2411	Preston	902	7.33	2.24	2.42	13.79	2.59	2.23
2397	Preston	884	8.58	2.11	2.34	13.34	2.53	2.16
2383	Preston	868	8.03	2.29	2.32	13.22	2.21	2.44
2414	Prseton	910	8.70	2.06	2.29	13.05	2.31	2.15
2388	Preston	874	9.17	1.96	2.26	12.88	2.36	2.23
2409	Preston	900	9.83	1.99	2.09	11.91	2.42	2.09
2405	Preston	891	9.21	2.08	2.02	11.51	2.88	2.33
2400	Preston	907	9.24	2.01	1.93	11.00	2.38	2.19
Average			8.67	2.10	2.26	12.91	2.52	2.24
2398	Marquis	885	7.83	2.16	2.12	12.08	2.46	2.53
2401	Marquis	887	9.05	1.87	2.09	11.91	2.38	1.99
2410	Marquis	895	7.77	1.99	1.98	11.29	2.75	2.28
Average			8.22	2.01	2.06	11.76	2.53	2.27
2374	Canada Red	901	8.05	2.35	2.40	13.68	2.70	2.41
2377	Canada Red	908	8.44	2.16	2.37	13.51	2.20	2.54
2373	Canada Red	899	8.46	2.14	2.35	13.40	2.63	2.53
2376	Canada Red	905	7.61	2.04	2.33	13.28	2.28	2.68
2375	Canada Red	904	7.93	2.09	2.12	12.08	2.50	2.49
2396	Canada Red	883	9.85	2.12	2.08	11.86	2.50	2.34
Average			8.98	2.16	2.32	13.20	2.46	2.53
2370	Unnamed	862	8.28	1.95	2.28	12.99	2.25	2.24
2415	Unnamed	911	8.29	1.91	2.16	12.31	2.49	2.23
2406	Unnamed	892	8.89	1.90	2.03	11.57	2.32	2.39
Average			8.49	1.92	2.16	12.29	2.35	2.29

Chemical Composition of Pure Lines of Wheat Grown at Aroostook Farm in 1918.—Concluded.

MINNESOTA LINES.

Accession No.	Selected from Variety	Moisture	Ash	Nitrogen	Protein (Nx5.7)	Fat	Crude Fiber
187	Marquis	8.04	2.01	2.44	13.91	2.85	2.23
186	Royalton (Red)	7.07	2.08	2.38	13.57	2.74	2.21
185	Royalton (White)	9.44	2.02	2.32	13.22	2.31	2.23
180	Haynes Bluestem	7.13	2.05	2.27	12.94	2.74	2.22
183	Velvet Chaff	9.20	1.97	2.26	12.88	2.46	2.14
182	Speltz Marz (durum)	8.80	1.93	1.83	10.43	2.50	2.08
Average for Minnesota lines		8.28	2.03	2.25	12.83	2.60	2.19
Average for Minnesota lines except durum		8.18	2.03	2.33	12.30	2.62	2.21

regard to which the crops of 1917 and 1918 differed. In 1917 the wheat lines did not grow on typical Caribou loam but on a darker soil with more abundant moisture and possibly more humus, which may have accounted for the higher protein content in 1917. Further, in 1917 the wheat lines all grew in one two-thousandth acre plots while in 1918 the area ranged from one two-hundredth to one-fortieth acre. The smaller tract occupied by the wheats in 1917 presented probably a greater uniformity of soil conditions than the larger area in 1918 which possibly accounted for a narrower range of variation in the protein content.

It will now be of interest to study the relationship between the protein content in 1917 and 1918. Considering first the varieties as a whole we note on consulting Tables 5 and 7 that notwithstanding the comparatively small differences in their protein content the varieties rank practically in the same order with respect to protein content in 1918 as they did in 1917. This is brought out more clearly by bringing together the average protein contents of the pure lines of each variety for each year as shown in Table 8. While the difference between the averages are small the data given in Table 8 indicate a tendency for the varieties as a whole to preserve their respective rank with respect to protein content.

As the average of these varieties are determined by the values of their component strains it will be instructive to examine the behavior of the individual lines with respect to their protein content from year to year. It will be remembered that 99 lines

TABLE 8.

Relation Between the Average Protein Content for the Pure Lines of Each Variety in 1917 and 1918.

Parent Variety of Pure Lines	Average Protein Content in per cent	
	1917	1918
Minnesota Lines	14.36	13.30
Canada Red	14.30	13.20
Preston	13.94	12.91
Bluestem	13.74	12.77
Unnamed	13.69	12.29
Red Fife	13.68	12.77
Marquis	13.29	11.76

were analyzed in 1917. In 1918 only 44 lines were continued and of these 40 were analyzed so that only for these 40 lines could the variation in the protein content in 1917 and 1918 be determined. The protein content of each line in 1917 was correlated with the protein content of the same line in 1918 with a resulting correlation coefficient of 0.381±.092. This coefficient as judged by its probable error is significant despite the small number of individuals, and indicates that with a number of pure lines here considered the protein content was transmitted from one year to the next. This is in accord with the observations reported by Freeman[21] who found for the character hardness or flintiness of wheat which is regarded as closely associated with high nitrogen, that the "differences (in percentage of hard grains) were varietal and tended to persist in the same strains from year to year." Freeman's pure lines were selected from a commercial variety of Turkey wheat and the percentage of hard grains in 1914 correlated with percentage of hard grains in 1915=57% ±4%; the percentage of hard grains in 1915 with percentage of hard grains in 1916=33%±5% (L. c. p. 27).

The degree of correlation between the protein contents of wheat varieties from one year to the next will depend upon the number of strains which under a given set of environmental condititions will tend to retain their relative rank with respect to

[21]Freeman, Geo. F. A Mechanical Explanation of Progressive Changes in the Proportions of Hard and Soft Kernels in Wheat. Jour. Am. Soc. Agr. 1918, v. 10, pp. 23-28.

protein content. Since the coefficient of correlation referred to above was obtained by grouping pure strains originally selected from different varieties it became a matter of interest to determine to what extent each of the respective parent varieties influenced the value of that coefficient. A tabulation of the different strains within each variety with respect to their relative rank in protein content in 1917 and 1918 brought out the fact that the varieties Canada Red, Preston, Red Fife and Unnamed furnished most of the strains which retained their relative rank in protein content from one year to the next, while with the Minnesota lines and the Marquis and Bluestem varieties the behavior of the lines with respect to this character was more erratic. It may be of interest to note in this connection that the varieties Preston, Canada Red and Red Fife which contained a large number of lines retaining their relative rank in protein content from year to year have been grown for years in Aroostook and Eastern Canada whereas the other varieties whose lines did not show a consistent behavior with respect to protein content have only very recently been introduced into Aroostook. This fact may serve to explain the different behavior of these two groups of strains with respect to their protein rank from one year to the next. A commercial variety is a mixed population composed of a number of different strains. These strains may possess a varied degree of response to the factors of environment of a given locality. If a commercial variety is grown for a number of years in one locality its component strains may be expected to have an established degree of reaction to the environment of that locality. Strains selected out of such a variety will tend to retain their relative rank in respect to a given quantitative character. On the other hand, varieties introduced into a new environment can not be expected in the first years of adaptation to segregate out strains with a fixed type of response to the new environment in regard to their quantitative characters. This brief consideration may acount for the different behavior of the local, Aroostook grown and the Minnesota strains.

BAKING TESTS OF THE PURE LINES.

The wheat of thirty-one pure lines of the 1918 crop was ground in a small experimental mill in the laboratory of the Russell-Miller Milling Co., Minneapolis, and the flour subjected to

a chemical analysis and a baking test in the laboratory of the Ward Baking Company, New York. The writer is greatly indebted to Dr. Chas. Hoffman, Chief Chemist of the Ward Baking Company for his careful study of these flours for strength and baking quality.

The results of the chemical analysis of these flours are given in Table 9. The lines are grouped according to their parent varieties and their dry gluten rank.

From Table 9 the considerable variations in the gluten content will be first noted. With a number of strains the percentage of dry gluten is rather high, several of the Aroostook lines exceeding the Minnesota lines in gluten content. Except for a few striking exceptions, there appears to be a relation between the amount and quality of gluten. The Red Fife and Bluestem varieties furnished a large number of strains with good quality glutens while the Preston, Unnamed and Marquis show a large percentage of strains with fair to poor quality of gluten. The Marquis lines showed uniformly short, stiff glutens of only fair quality. The Minnesota lines with the exception of durum and Marquis furnished strong glutens of good quality.

The data from the baking test with regard to water used, volume of loaf, texture, color of crumb and external appearance of loaf are presented in Table 10. According to Dr. Hoffman's report the following ingredients were used in each case:

Flour	300 grams
Water	Amount to give correct stiffness
Sugar	20 grams
Salt	4½ grams
Yeast	5 grams
Arkady Yeast Food 1½ grams	

Temperature set 82° F.

Time of fermentation 4¼ hours. This is the time when the dough is mixed until it is moulded ready for the pan.

All doughs were well moulded by machinery, but mixed by hand. Baking was done under factory conditions.

TABLE 9.

Results of Chemical Analysis of Flours From Pure Lines of Wheat Grown at Aroostook Farm. 1918 Crop.

AROOSTOOK LINES.

Line No.	Selected from Variety	Ash per cent	Moisture per cent	Gluten Wet per cent	Gluten Dry per cent	Ratio Wet to Dry Gluten	Condition of Gluten
2390	Red Fife	0.70	8.40	37.96	13.13	2.89	Soft and sticky—weak gluten
2385	Red Fife	0.60	8.50	36.50	12.74	2.87	Soft elastic gluten with good expanding quality
2389	Red Fife	0.70	8.30	33.55	12.18	2.75	Tough gluten of fair quality
2386	Red Fife	0.67	8.38	32.78	11.78	2.78	Tough, strong gluten
2379	Red Fife	0.66	8.50	33.60	11.78	2.85	Gluten strong and elastic
2393	Red Fife	0.68	8.30	33.70	11.67	2.88	Good quality gluten, strong and elastic
2395	Red Fife	0.70	8.50	32.25	11.26	2.89	Medium quality gluten—somewhat dead
Average		0.67	8.41	34.33	12.08	2.83	
2391	Bluestem	0.77	8.40	35.40	12.35	2.87	Tough, elastic gluten
2387	Bluestem	0.74	8.32	34.55	12.25	2.82	Very good, strong gluten
2394	Bluestem	0.78	8.47	33.85	11.95	2.83	Strong, tough gluten
2384	Bluestem	0.67	8.57	32.05	11.28	2.84	Medium softness with fair quality
Average		0.74	8.44	33.88	11.98	2.84	
2402	Preston	0.72	8.53	40.38	13.26	3.04	Soft and sticky, strength poor
2397	Preston	0.66	8.60	39.93	12.84	3.19	Soft and elastic—good quality
2383	Preston	0.86	8.70	37.47	12.83	2.92	Gluten soft and sticky, fair quality
2414	Preston	0.68	8.14	35.05	12.30	2.85	Elastic gluten of very good quality
2388	Preston	0.64	8.20	35.45	12.13	2.92	Strong gluten with very good expanding quality
2409	Preston	0.79	8.53	34.25	11.85	2.89	Very soft and sticky
2405	Preston	0.79	8.38	32.85	11.23	2.93	Soft dead gluten—no elasticity
2400	Preston	0.74	8.78	31.50	10.89	2.80	Soft sticky, of poor quality
Average		0.74	8.48	35.86	12.17	2.94	
2398	Marquis	0.81	8.80	31.83	11.69	2.72	Stiff, tough gluten—shows fair quality
2410	Marquis	0.77	8.49	29.20	10.60	2.75	Short, stiff gluten, fair strength
Average		0.79	8.65	30.52	11.15	2.74	
2373	Canada Red	0.70	8.50	39.21	13.23	2.96	Soft but elastic and of good quality
2396	Canada Red	0.69	8.20	31.48	10.80	2.91	Soft and sticky, very low quality
Average		0.69	8.35	35.35	12.02	2.94	

Results of Chemical Analysis of Flours From Pure Lines of Wheat Grown at Aroostook Farm. 1918 Crop.
—Concluded.

Line No.	Selected from Variety	Ash per cent	Moisture per cent	Gluten Wet per cent	Gluten Dry per cent	Ratio Wet to Dry Gluten	Condition of Gluten
2415	Unnamed	0.62	8.40	37.40	12.22	3.06	Soft and sticky, lacks strength
2370	Unnamed	0.70	8.42	32.65	11.53	2.83	Soft, dead gluten—no life
2406	Unnamed	0.66	8.56	29.53	10.31	2.86	Soft, putty-like gluten
Average		0.66	8.46	33.19	11.35	2.92	

MINNESOTA LINES.

Accession No.	Selected from Variety	Ash per cent	Moisture per cent	Gluten Wet per cent	Gluten Dry per cent	Ratio Wet to Dry Gluten	Condition of Gluten
186	Royalton (Red)	0.74	8.20	36.28	12.69	2.86	Very good gluten with strong expansive qualities
185	Royalton (White)	0.68	8.28	34.28	12.28	2.81	Strong, elastic gluten
180	Haynes Bluestem	0.72	8.30	34.40	11.83	2.91	Tough and strong
187	Marquis	0.77	8.30	32.25	11.56	2.79	Short and stiff of medium quality
182	Speltz Marz (durum)	0.90	8.49	27.00	9.93	2.72	Very dead-like and non-elastic
Average		0.76	8.31	32.84	11.66	2.82	
Average (excluding durum)		0.73	8.25	34.30	12.09	2.86	

In Table 10 the pure lines are grouped within their parent varieties according to the volume, expressed in cubic centimeters, of bread loaf produced from their flour. A photograph of each loaf baked from the flour of each strain is given in the accompanying figures. From these photographs the size, volume, texture and general appearance of each loaf will be noted. A study of the data given in Table 10 will show a number of strains producing a bread of good volume and very good appearance. As in the case of other characters the variation in the size of bread loaf is very marked. The Red Fife line No. 2393 produced a

bread loaf with the highest volume—2221cc.—of very good texture and good color. Very similar qualities were shown by the Bluestem line 2391 with a loaf volume of 2209 c.c. The third highest loaf volume was produced from flour of another Red Fife strain—No. 2385. The best Minnesota line, Royalton (Red) ranks fourth in volume of loaf. On comparing the data from

TABLE 10.

Baking Tests of Flours from Pure Lines of Wheat Grown at Aroostook Farm. 1918 Crop.

AROOSTOOK LINES

Line No.	Selected from Variety	Grams of water used	Loaf Volume in cubic centimeters*	Texture	Color of Crumb	External Appearance
2393	Red Fife	210	2,221	Very good	Good	Excellent baking quality—produced nice appearing loaf
2385	Red Fife	213	2,153	Close	White with velvety sheen	Very good size and appearance. Excellent baking qualities
2390	Red Fife	210	2,028	Good, close	Good	Flour produces good sized loaf, but lacks baking strength
2389	Red Fife	210	2,028	Very good	Good	Volume good. Has strength and makes good appearing loaf
2386	Red Fife	210	2,017	Fair	Fair	Tendency of dough to tear during proofing, causing a rough appearance of loaf
2379	Red Fife	205	1,903	Very good	White	Size of loaf fair but flour shows good baking quality
2395	Red Fife	210	1,881	Coarse	Fair	Poor baking qualities, appearance of loaf fair
2391	Bluestem	210	2,209	Very good	Good	Very good appearing loaf. Flour has good baking strength
2394	Bluestem	210	2,096	Fair	Fair	Volume good. Flour has good baking qualities
2387	Bluestem	210	1,983	Poor	Fair	Volume good. Flour shows strength and qualities
2384	Bluestem	205	1,813	Fair	Good	Fair size to loaf, fair baking quality
2388	Preston	210	2,068	Close	Very good—white	Volume good. Appearance good. Baking quality very good
2397	Preston	205	2,028	Very close	Good	Volume good. Shows good baking qualities
2414	Preston	210	1,983	Very good	Very good	Good volume and appearance. good quality for baking
2402	Preston	205	1,892	Good	Good	Good appearing loaf. Gluten lacks strength for good baking results

Baking Tests of Flours from Pure Lines of Wheat Grown at Aroostook Farm. 1918 Crop.—Concluded.

Line No.	Selected from Variety	Grams of water used	Loaf Volume in cubic centi-meters*	Texture	Color of Crumb	External Appearance
2400	Preston	200	1,869	Fair	Fair	Has poor baking qualities. Lacks strength to give proper expansion
2383	Preston	205	1,858	Fair	Dark	Appearance good. Has good baking qualities
2409	Preston	200	1,858	Good	Fair	Poor quality for bread baking
2405	Preston	200	1,773	Close	Dark	Fair appearing loaf, but gluten too dead to give proper expansion
2398	Marquis	210	1,949	Good	Dark gray	Volume good. Flour has strength for baking
2410	Marquis	210	1,858	Coarse	Fair	Fair baking quality
2373	Canada Red	205	2,017	Good	Good	Volume good but strength too low for good baking results
2396	Canada Red	205	1,745	Coarse	Dark	Volume poor. Appearance of loaf fair. Poor baking qualities
2415	Unnamed	200	1,926	Close	Fair	Appearance of loaf fair, but gluten too weak to prevent tearing on the side of loaf
2370	Unnamed	200	1,756	Coarse	Dark	Appearance of loaf good but lacks volume. Quality lacking
2406	Unnamed	190	1,518	Very coarse	Dark	Very poor quality flour for bread baking

MINNESOTA LINES

Accession No.	Selected from Variety	Grams of water used	Loaf Volume in cubic centi-meters*	Texture	Color of Crumb	External Appearance
186	Royalton (Red)	210	2,079	Good	Slightly gray	Very good volume and appearance. Very good quality
185	Royalton (White)	210	2,028	Good, close	Good	Volume and expansion showed good quality
187	Marquis	210	1,903	Very coarse	Dark	Fair appearance of loaf, but flour lacks strength
180	Haynes Bluestem	210	1,881	Close	Slightly gray	Size of loaf good, appearance good. Baking qualities very good
182	Speltz Marz (durum)	190	1,360	Very coarse	Dark	No strength to give size and appearance to loaf

*Calculated to 340 grams of flour per each loaf.

the baking test with the results of the chemical analysis of the flours it will be noted that the quality of gluten is very well reflected in the volume and appearance of the bread loaves. With a few rather striking exceptions the volume of loaf appears to follow in a number of cases also the quantity of gluten. This point will be recurred to later.

Since the volume of loaf is at present the most reliable index of flour strength, and further, one of the most important factors in determining the commercial value of bread wheat, it will be of interest to determine how the wheats from the pure lines here considered would rank among the chief American wheats. We may here again refer to the study of several classes of American wheats by L. M. Thomas.[22] On the basis of extensive baking tests involving 1386 samples Thomas found the following average volume for each of the five classes of American wheats:

Soft white	1,907 c.c.
Soft red winter	1,965 c.c.
Durum wheat	2,070 c.c.
Hard red winter	2,219 c.c.
Hard red spring	2,421 c.c.

Comparing our best line 2393 having a volume of 2,221 c.c. we find that it falls just 200 c.c. short of the average volume of its own class of wheat, the hard spring wheat. From a diagram in Thomas' bulletin in which the distribution of the 574 samples with regard to volume in the hard spring wheat class are illustrated we may note that about 15 per cent of hard spring wheat samples had a loaf volume lower than some of our best lines. Further reference to the average loaf volume of American wheats given above, shows that our best lines furnished a loaf volume very considerably higher than the average of the two classes of soft wheat, a higher than the average of the durum class, and equal to the average of the hard red winter class. From this comparison we note that our best lines of wheat are as strong as 15 per cent of the hard red spring wheats and 50 per cent of the hard red winter wheats.

The data given by Thomas are based on samples taken from the crops of 1908 to 1913 inclusive. If we should consider the

[22]L.c. pp. 18-19.

strength of wheats determined for one year in a state growing some of the best spring wheats, for instance, North Dakota, we would find that the size of loaf of our best lines approaches still closer the size of the strong wheats grown there. Thus in a report on the baking data for the 1915 crop of North Dakota[23] wheat we find that the average loaf volume of Bluestem, Fife, Velvet Chaff and Marquis, including all grades is 2307 c.c. Including only the two best paid classes of these four wheats, No. 1 Hard, and No. 1, the average volume of loaf from the flour of these two grades of wheat is only 2271 c.c. or only 50 c.c. above the volume of the best of our pure strains. While these comparisons are not quite fair they nevertheless convey some idea as to the possibilities of growing strong wheats in Northern Maine.

Relative to other points determining the quality of bread, reference to Table 10 will show that the texture and color of crumb with a relatively large proportion of the pure strains was found to be good or very good. Especially the strains of the Red Fife and Preston varieties excel on this point. Most of these breads possessed excellent eating qualities.

RELATION BETWEEN PROTEIN, GLUTEN CONTENT AND SIZE OF BREAD LOAF.

With the data on crude protein, dry gluten and loaf volume for these pure lines at hand it is very desirable from the breeding point of view to examine if there is any relation between these three characters which would be of diagnostic value in the breeding work. In Table 11 the pure lines are grouped within their respective parent varieties in the order of their crude protein content with the corresponding rank in gluten and loaf volume.

An inspection of Table 11 will reveal an undeniable relationship between the crude protein content, dry gluten and the size of loaf. While this relation is not quite regularly consistent it is nevertheless distinct. In regard to the degree of relationship between these three factors the data given in Table 11

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[23]Sanderson, Thomas. The Milling and Baking Data for the 1915 Crop of Wheat. 1917, N. Dakota Bull. No. 132, pp. 61-94.

TABLE 11

Relative Rank of the Pure Lines with Respect to Crude Protein, Dry Gluten and Loaf Volume. 1918 Crop.

AROOSTOOK LINES.

Line No.	Variety	Crude Protein		Dry Gluten		Loaf Volume	
		per cent	Rank	per cent	Rank	c.c.	Rank
2385	Red Fife	14.54	1	12.74	2	2,153	2
2390	Red Fife	13.79	2	13.13	1	2,028	3
2389	Red Fife	12.83	3	12.18	3	2,028	4
2393	Red Fife	12.20	4	11.67	4	2,221	1
2379	Red Fife	12.20	5	11.78	5	1,903	6
2386	Red Fife	12.14	6	11.78	6	2,017	5
2395	Red Fife	11.74	7	11.26	7	1,881	7
2391	Bluestem	13.34	1	12.35	1	2,209	1
2394	Bluestem	12.65	2	11.95	3	2,096	2
2387	Bluestem	12.48	3	12.25	2	1,983	3
2384	Bluestem	11.91	4	11.28	4	1,813	4
2402	Preston	13.79	1	13.26	1	1,892	4
2397	Preston	13.34	2	12.84	2	2,028	2
2383	Preston	13.22	3	12.83	3	1,858	6
2414	Preston	13.05	4	12.30	4	1,983	3
2388	Preston	12.88	5	12.13	5	2,068	1
2409	Preston	11.91	6	11.85	6	1,858	7
2405	Preston	11.51	7	11.23	7	1,773	8
2400	Preston	11.00	8	10.89	8	1,869	5
2398	Marquis	12.08	1	11.69	1	1,949	1
2410	Marquis	11.29	2	10.60	2	1,858	2
2373	Canada Red	13.40	1	13.23	1	2,017	1
2396	Canada Red	11.86	2	10.80	2	1,745	2
2370	Unnamed	12.99	1	11.53	2	1,756	2
2415	Unnamed	12.31	2	12.22	1	1,926	1
2406	Unnamed	11.57	3	10.31	3	1,518	3

MINNESOTA LINES.

Accession No.	Variety	Crude Protein		Dry Gluten		Loaf Volume	
		per cent	Rank	per cent	Rank	c.c.	Rank
187	Marquis	13.91	1	11.56	4	1,903	3
186	Royalton (Red)	13.57	2	12.69	1	2,079	1
185	Royalton (White)	13.22	3	12.28	2	2,028	2
183	Haynes Bluestem	12.94	4	11.83	3	1,881	4
182	Speltz Marz (durum)	10.43	5	9.93	5	1,360	5

indicate a close relation between the protein and dry gluten. Indeed, the ranks of the crude protein and the dry gluten are completely indentical for the strains of the Preston, Marquis,

Canada Red, and nearly identical for the strains of Red Fife and Bluestem. In regard to the relation of the two chemical components, protein and gluten, to the baking strength there appears to be, on the whole, some relation between the gluten content and size as well as a still less consistent relation between protein and loaf volume.

These relations are of importance especially as they have been established in this case for pure strains of wheat grown at one limited centre, when the evidence for or against these relations has hitherto been based almost exclusively on analysis of samples from commercial varieties. In this connection it is of special interest to cite the results of two chemists, who worked with materials of an entirely different nature. Shutt[24] analyzing flours from wheats representing for the most part pure strains selected and bred pure by Dr. Chas. E. Saunders arrived at the conclusion that "between the protein, gliadin and wet and dry gluten there is a distinct relationship, but there is no evidence of a definite or absolute ratio. The results from both series of flours clearly indicate a distinct relationship between these chemical data (protein, gliadin and gluten) and 'baking strength' —a figure made up chiefly of the values for volume, shape and weight of loaf." Olson,[25] on the other hand, working with samples of flours from unidentified varieties and received from mills located in 12 different States concluded that there is no relation between the quality of the flour and the total nitrogen and gluten content. "The volumes of loaves appeared to be inversely proportional to the gluten content."

DISCUSSION AND CONCLUSIONS.

An analysis of the data here presented brings out the fact that pure strains of wheat isolated from commercial varieties when grown under the same environmental conditions show very distinct differences with respect to the physical and chemical characteristics and the bread making value of their grain. The very small tract of land upon which these pure lines grew,

[24]Shutt, T. F. The Relationship of Composition to Bread-making value. 1907. Centr. Exp. Farm, Can. Bull. 57, pp. 27-51.

[25]Olson, G. A. Wheat and Flour Investigations—V, 1917, Wash. Agr. Exp. Sta. Bull. No. 144, pp. 1-86.

and for which a very considerable degree of homogeneity may safely be assumed, lends particular significance to these differences. For one of these characters, viz, the crude protein content, whose behavior alone could be studied from one year to the next, it was shown that these differences are not mere fluctuations but the result of inherent tendencies as evidenced by the coefficient of correlation between the values of one year and those of the next. Of the physical characteristics the kernel weight, the hardness as measured by the percentage of yellow berries, and the color show marked differences. Even in the nursery rows where the strains grew side by side the degree of hardness of the different lines was so marked that out of the original 259 strains 158 were discarded as being soft and opaque. This character while very susceptible to the environment is regarded by Freeman (Loc. cit. 1918) as being controlled by genetic factors which determine the greater or less sensitivity of this character to the environment. Leith,[26] who also studied the inheritance of the yellow berry, found that while there is no difference between the yellow and hard berry of the same pure line in the production of yellow berry in their progeny, there is a very considerable difference between pure lines in their tendency to reproduce hard berries.

No less pronounced are the differences between the individual lines with respect to the chemical characteristics as will be seen from Tables 5 and 7. The average protein content for all strains in 1917 was higher than in 1918. But in spite of the seasonal variation of the environment affecting the absolute quantity of the protein the fact remains that the individual strains tended to retain their relative protein rank regardless of the seasonal average for this character.

From the close association between protein and gluten it may be inferred that there is a tendency for the pure strains to retain also their gluten rank, though there has been no opportunity yet to study the behavior of this character from year to year.

Perhaps the most pronounced differences between the pure lines are reflected in the quality of their glutens and in the size of bread loaf baked from their flours, as shown in Tables 9 and 10. While the present data do not convey any informa-

[26] B. D. Leith, Loc. cit.

tion as to whether these two characters are heritable, the results secured by Biffen[27], Howard, Leake and Howard[28] and Leith[29], furnish substantial evidence showing that strength in wheat is a heritable character retained even under very unfavorable environmental conditions of England and parts of India.

From the data reported in this bulletin it is evident that under the same conditions of environment some strains of wheat will retain a higher degree of hardness, a higher amount and better quality of gluten and produce a larger size of bread loaf than others. The logical deduction from this is that the individuality of the seed, the inherent characteristics of the wheat strain should enter as an inportant factor into the consideration of the chemical composition and bread making value of wheat.

The present data while covering only a very brief period are nevertheless of practical importance in their bearing upon the possibilities of growing good bread wheats in Northern Maine. Owing to the excellent adaptiveness of Aroostook soil and climate to the potato crop the area devoted to wheat in Aroostook is rather small and the growing of wheat in that section will be largely a problem of meeting primarily the local consumption, in other words, the growing of wheat in Aroostook will be concerned above all in raising good bread wheats for home baking. As to the question of raising good flour for home baking in Aroostook it is believed that our data offer a very satisfactory solution. We quote in this connection from the report of Dr. Hoffman, chief chemist of the Ward Baking Company, upon the baking test of our flours: "A number of the flours showed good quality glutens and made bread of very good quality. For home baking most of these flours are satisfactory and will produce a loaf with excellent eating qualities."

It is, of course, impossible, as yet, to say that the best pure lines so far selected represent the highest limit of baking strength under Aroostook conditions. Only results from a large number of selected strains tested for several years can give an answer to this question.

Until superior strains best adapted to Aroostook conditions are developed through selection or breeding the practical ques-

[27]Biffen, R. H. Loc. cit. 1908.

[28]Howard, Albert, Leake, H. M. and Howard, G. L. C. Loc. cit.

[29]Leith, B. D. Loc. cit.

tion arises as to whether local or imported wheat should be used for seed. The best policy would be to secure local varieties of wheat of known performance in regard to yield and milling and baking quality. Such wheat varieties, however, are not generally available, and it has been a common practice with the Aroostook grower to import his wheat seed, usually from the Northwest. In importing wheat seed the practice of buying seed from mixed car lots of unknown varieties should be discouraged. Our experience with the Minnesota strains clearly indicates that in order to secure a satisfactory seed it is not enough to import hard wheats from the Northwestern Plains, for certain varieties and strains show a greater capacity for adaptation to humid regions than others. Thus the two strains of the Royalton wheat retained strength under Aroostook conditions yielding grain with a high percentage of protein, very good gluten with strong expansive qualities and good appearing loaves of good volume and very good quality. On the other hand the Marquis strain yielded a gluten with only medium quality and a flour lacking in strength. From this it is evident that an imported variety will first have to be tested for its capacity for retaining its strength under Aroostook conditions, and it is, therefore, essential not only to import seed from known varieties but that these varieties should be as free from admixtures as this is possible with commercial varieties. The more a variety approaches the condition of a pure strain the sooner and the more certain will its degree of adaptability to new conditions be determined.

While no definite recommendations can be made, as yet, as to the best variety for Aroostook conditions, our data furnish some information which may be of practical value. Under Aroostook conditions the Marquis strains did not make a good showing. They all yielded flour with short stiff gluten of only fair quality. Coupled with this rather low quality is a low yielding capacity. This is rather unfortunate as the early maturity of the Marquis would make this variety otherwise very desirable for Aroostook conditions.

The Preston strains are good yielders but only a few excel in quality though a number of them showed a high protein content. The growing of strong strains of the Preston group should be encouraged as they are well adapted to the conditions of Northern Maine.

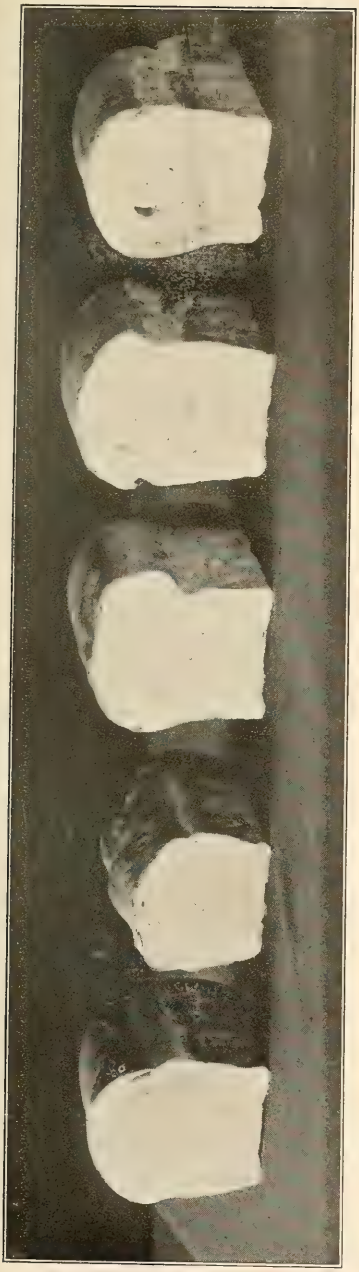
The Canada Red strains (Ladoga type), while good yielders should be dropped on account of their low bread making quality. The Aroostook wheats are frequently mixed to a greater or less degree with these strains which probably lower the quality of the resultant flour.

The Red Fife and Bluestem varieties furnished the strongest strains yielding flour of very good to excellent baking quality. The Bluestem variety, however, is somewhat later than the Red Fife which is some drawback under Aroostook conditions. Its straw is perhaps not quite so strong as would be desirable and its hairy chaff tends to retain more moisture than the smooth chaffed varieties which may favor the attack by fungi and retard the maturing of the grain.

The Red Fife variety appears to be the best choice. The Red Fife strains yielded the strongest flour and have also a satisfactory yielding capacity. The Fife wheats have grown for a number of years in Aroostook County and are well adapted to the conditions of that section. From our experience and the results obtained in England, Canada and Australia it appears that the Red Fife wheats are characterized by a high capacity for adaptation and a strong tendency to retain their strength under unfavorable conditions of environment.

EXPLANATION OF PLATES.

The photographs on plates I, II, and III represent loaves of bread baked from flour of the pure lines of wheat grown at Aroostook Farm. The number under each loaf refers to the line of the wheat strain, except the first five loaves where the figure designates the accession number. Each loaf was baked from 300 grams of flour so that the size of these bread loaves is directly comparable. Note the variation in volume of loaves and texture of crumb.

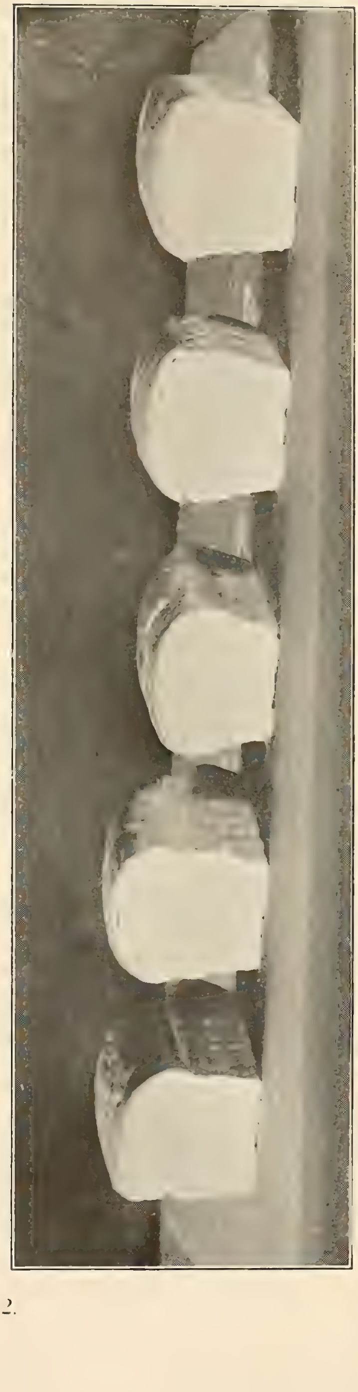


217 186 185 182 180

2384 2383 2379 2373 2370

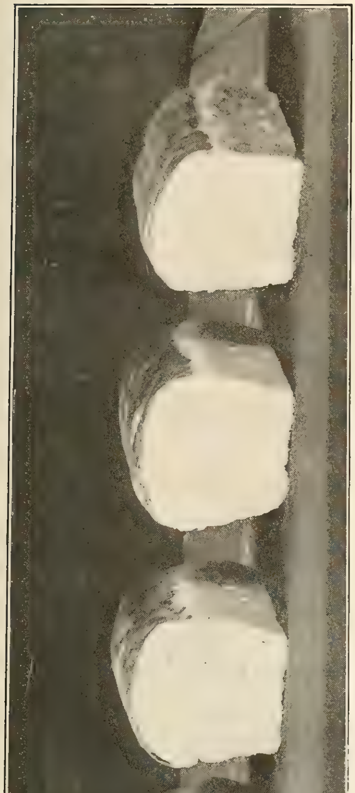
Plate 1.

2385 2386 2387 2388 2389

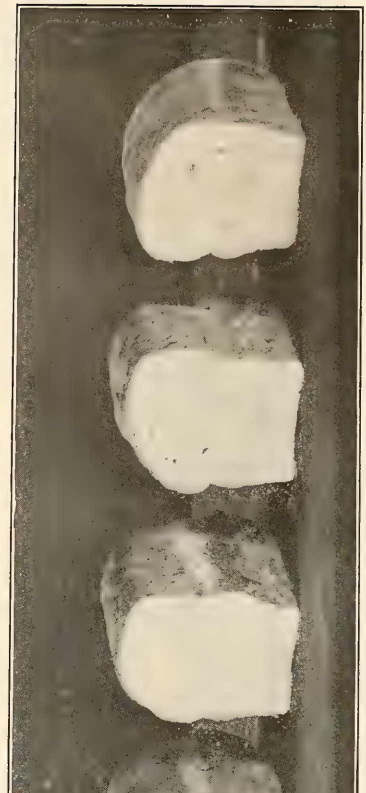


2402 2405 2406 2407 2409

Plate 2.



2396 2397 2398 2399 2400



2390 2391 2393 2394 2395

PLATE 3.

BULLETIN 286

THE VARIATION OF MILK SECRETION WITH AGE IN JERSEY CATTLE.*

JOHN W. GOWEN.

SUMMARY

The yield of milk changes definitely with age. The change is a logarithmic change not as commonly supposed a linear change.

The variation of milk yield from cow to cow also changes definitely with age. This change is described by a parabolic function.

The curve for growth is logarithmic. The similarity of the two curves suggests the increase in milk production with age could be accounted for by growth of the mammry gland.

A large body of exact scientific data on milk production has been accumulated since the time of the establishment of the Advanced Registry system of the Holstein-Friesian Association of America and its later adoption by the associations of the other breeds of dairy cattle. These completed records are unique in several ways, chief among which is the fact that the records of the cows included among them must meet a certain standard of performance. This standard for entry has the effect of cutting out certain records of cows of the given breed. Thus the Jersey Registry of Merit say that, "if the test is commenced the day the cow is two years old, or previous to that day, she must produce, within one year from the date the test begins, 250.5 pounds butter-fat. For each day the cow is over two years at the beginning of her year's test, the amount of butter-fat she must produce in the year is fixed by adding 0.1 (one-tenth) of

*This paper is an abstract of a longer paper on "Studies in Milk Secretion V. On the Variations and Correlations of Milk Secretion with Age in Jersey Cattle by the same author published in Genetics, March 1920. All literature citations should be made to this complete paper.

a pound for each such day to the 250.5 pounds required when two years old. This ratio of increase applies until the cow is five years old at the beginning of her test, when the required amount will have reached 360 pounds, which will be the amount of butter-fat required of all cows five years old or over. These standards are based upon one complete year's record from the time of beginning, regardless of any time which may be lost by being dry or calving during the period." Three facts are obviously true of the Jersey Registry of Merit cows as compared with a true sample taken at random of the milking cows of the Jersey breed; (1) the cows making up the Registry of Merit are a selected sample; (2) the scale of the selection is linear having its lower limit 250.5 pounds of butter-fat production at 2 years and its upper limit 360 pounds at 5 years and over; (3) this requirement means that for each day of age at test the frequency distributions of years production are cut off perpendicularly at the requirement and only those animals making greater yields than this are allowed to be entered into the Registry of Merit. The data taken from this Registry of Merit are not the true data for the Jersey breed and conclusions based on it cannot be considered as applying to the breed as a whole or to the general problems of milk secretion.

To supply this need of exact data on the Jersey breed as a whole the Maine Agricultural Experiment Station has obtained the recorded data of one of the largest pure bred Jersey herds known. The data are exceptional in the following ways: (1) The records extend back to the year 1897 when the herd was organized; (2) the animals are practically all straight island stock; (3) they have been under the oversight and direction of one manager since 1901; (4) exact records are kept of the milk production, butter-fat and butter-fat per cent; (5) many of the individual animals have records for several different lactations. The elimination of variation of the milk production of cows or groups of cows caused by changes in any one or more of these five factors is important for the analysis of the causative mechanism of milk and butter-fat production. It is obvious that these records are free from such variables. They constitute a homogeneous group of data representing the island Jersey under constant conditions of management and climate.

Such an accumulation of exact statistical data on the cows of the Jersey breed for problems of so much interest, both biologically and economically, warrants the application of adequate biometrical methods in their analysis. The necessity of such analysis is now well recognized by most investigators as of the utmost importance to our understanding of the fundamental principles of physiology which underlie the process of milk secretion itself.

The general problems attacked are those of the individual variation between the lactating functions of different dairy cows at a given age. What is the true type of the frequency distributions of milk production? What relation exists between the mean productions of the successive ages in a true random sample of the Jersey breed? An understanding of these and similar questions is necessary to the fuller utilization of the data found in the herd book of the registry association.

The data used for study are all from normal, healthy cows. Two diseases have been present in the herd, tuberculosis and abortion. The tuberculous animals were all eliminated early in the herd's history by the use of the tuberculin test. All records from animals which were proven to be tubercular or which aborted were not used. Records from animals normally healthy but sick during a given lactation were not used. All of the cows have been kept in climatic conditions similar to those of Western Virginia.

A word as to the method of keeping the data and its transfer to this Station. All records are made at the time of milking on the daily milk sheet for the given cow which are kept in the barn. The milking takes place twice a day, the records are for night and morning. The weekly production taken from these sheets is transferred to the herd ledger by a trained bookkeeper. The total production for a given month is found together with the yearly production by adding the weekly totals. All records are recorded to pounds and tenths. The cows are tested bi-monthly by the Babcock test and the percentage of butter-fat is recorded beside its corresponding monthly milk yield. All weighings and readings are recorded immediately after they are made so there is little chance of inaccuracy. From these records the author has extracted 1741 complete 8 months records of healthy cows for milk production. Of these 1741,

1713 have records for the butter-fat percent. The weighed monthly averages of the bi-monthly test have been used to obtain the weighed 8 months average for the 8 months lactation period chosen for study.

VARIATION OF JERSEY MILK PRODUCTION WITH AGE AT COMMENCEMENT OF TEST.

The tabulation of these records in complete eight months records has been done by the author. The chief physical constants of the distributions are presented in table 1 together with their probable errors.

TABLE 1.

Constants of Variation of Milk Production for the Successive Ages at Test in Jersey Milk. (8 Months Lactation Period).

Age at Test	Mean	Standard Deviation	Coefficient of Variation	Skewness
2 years 0 months to 3 years 0 months	4032.9±31.7	818.9±22.4	20.304± .577	
3 years 0 months to 4 years 0 months	4686.5±46.8	1101.5±33.1	23.503± .712	+0.2642±.0548
4 years 0 months to 5 years 0 months	4992.9±46.3	1079.4±33.0	21.619± .684	+0.3532±.0635
5 years 0 months to 6 years 0 months	5281.4±57.0	1262.8±40.3	23.911± .801	+0.3894±.0714
6 years 0 months to 7 years 0 months	5536.5±64.5	1325.3±45.6	23.938± .865	+0.2586±.0628
7 years 0 months to 8 years 0 months	5314.7±64.9	1255.0±45.9	23.613± .907	
8 years 0 months to 9 years 0 months	5226.4±77.9	1302.0±55.1	24.912±1.111	+0.3141±.1173
9 years 0 months to 10 years 0 months	4938.2±95.3	1302.6±67.4	26.377±1.453	
10 years 0 months and above	4838.8±70.3	1077.3±49.7	22.264±1.028	
Total population	4887.6±20.2	1249.7±14.3	25.569± .310	+0.3150±.0222

The mean milk production for the eight months period, for those cows which are between 2 and 3 years of age, is 4032.9 pounds. From this point the milk production rises rapidly at first then more slowly to a maximum at about 7 years. From this maximum the decline in milk production is less rapid toward the higher ages.

The difference between the production of 2 years and 6 months and the maximum is significant as the difference is about 20 times its probable error (1503.6±71.9). The difference between the maximum production and that for the 10 years and above is also significant as the difference is more than 6 times the probable error (697.7±95.40). This rise and fall of milk

production with age has already been shown, by the work of this laboratory, to conform to that group of curves described by a logarithmic function.

The standard deviation varies between 818.9 pounds at the age of 2 to 3 years to 1325.3 pounds at the age of 6 to 7 years. The rise of the standard deviation is more direct than is the rise of the mean curve. From the maximum the curve remains parallel with the base line for some years when it again drops to a lower deviation at the highest age at test. This rise and fall is significant as judged by the probable errors of the difference. The difference of the maximum standard deviation at 6 to 7 years from that at 2 to 3 years is 506.4 pounds of milk where the probable error is 50.8 pounds or the difference is practically 10 times the probable error and the probability that this difference did not come from random sampling is considerably greater than 1,000,000,000 to 1. The difference between the maximum standard deviation and that at 10 years and above is 248.0 pounds and the probable error is 67.5 pounds or 3.68 times the probable error and the probability that this difference did not come from random sampling is 75.7 to 1. From these above facts the conclusion seems justified that milk production varies with age at test in such a way that the absolute amount of the variation in production from one cow to another is least at the early age, increases rapidly to a maximum at about 5 years and 6 months, remains at this maximum for about four years then falls again toward the later ages.

The coefficient of variation for the milk production of the successive ages are all high as compared with those already

TABLE 2.

Comparison Data for Coefficients of Variation of Amount of Secretion.

Organism	Secretion	Coefficient of Variation	Source of Data
Domestic Fowl (Barred Plymouth Rock)	Annual Egg Production	34.21±.37#	Pearl
Cattle British Holstein	Gallons of milk	25.72±.37	Gavin
Cattle Ayrshire	Gallons of milk	24.18±.50*	Vigor
Cattle Jerseys	Pounds of milk	25.56±.31	This paper

#Probable error calculated by author from total given in paper.
*Calculated by the author from the means and standard deviation as given by Mr. Vigor.

known for other similar data. This large size in the coefficients is brought out by table 2.

Of the substance studied annual egg production is the most variable. The coefficient of variation for milk production corresponds remarkably well considering the diversity of the sources from which they are taken. They all go to show that milk production varies around a mean of 25 or is about 9 per cent less variable than egg production. This difference is significant. The mechanism of the secretion of the sum of the egg parts to form the egg is shown to be more variable than that for the secretion of the milk parts to form the milk. Taking this reasoning back to its ultimate source, such a significant difference shows that the secretory cells of the mammary glands work with greater precision than do the cells of the oviduct. Such a difference in the variation of action of the two sets of cells would seem to indicate a greater approach to perfection, in a mechanical sense, in the cells of the udder than is true of the cells of the oviduct.

The skewness of the two sets of data furnish another interesting contrast. The skewness of annual egg production for Barred Plymouth Rock hens is —0.205, whereas the skewness for Jersey milk production is +0.315. Not only is the sign different but the actual amount is different. This cannot be explained on the basis of any selection for high producers that may have taken place as both sets of data are about equally subject to such selection. The data for the successive age groups all goes to show that where the distributions for milk production are skew they are all plus. This lends further strength to the belief that the distribution for the yearly production of the two sets of glands is skew in opposite directions. One thing is common in the two cases, the skewness in each is small in amount. This is of especial importance as it shows the approach to the value where the typical Gaussian curve of error may describe these functions.

This question is of great importance in considering the milking records of advanced registry animals where it is necessary to form an opinion of the capacities of a breed from the milking abilities of a selected sample where the selection is not at random but removes those cows producing under a certain amount.

This feature of the problem is seen in the work of Reitz (1909) on the inheritance of butter-fat production in Holstein-Friesian cattle. The data for this problem came from the advanced registry of Holstein Friesian cattle. Since as a requirement to entry in this registry the cows must produce more than a certain amount of butter-fat, the correlation from such data measuring the strength of inheritance are subject to a double selection. Rietz in correcting for this selection uses the method devised by Pearson to determine the whole of a normal curve when a portion of it is known. The accuracy of the corrections depends then on the curves for milk production and for butter-fat percentage being normal.

When the frequency curves for milk production of these data are anlayzed by the method of moments for their type equations it is found that five of the curves belong to the type I group, four to the type II group and one to the type IV group. Nine of the ten curves are of limited range. These limits are of interest as they indicate the maximum and minimum productions to be expected from this group of cows. The limits of the range of the type II curves are on the whole somewhat underestimated. The type I curves more nearly record the facts of the case save in the curve for the total population where the range is considerably overestimated due to the slow approach to zero of the ends of the distribution. For such a distribution it must be remembered that the frequency becomes very small as the ordinary limits of the observation are passed.

On the whole the fit of the curves is excellent comparing favorably with that of any similar data. It is evident therefore that the skew frequency curves describe these data well. The question now arises in view of the difficulty of correcting for this skewness in correlation studies on the heredity of milk production, if the fit of the Gaussian curves is sufficiently good to allow of the use of this method.

When these curves are used it is found that the normal curves do not describe milk production at the different ages or for the total curve as well as do the proper type curves. The difference in the fit of the type curves over the normal curve comes especially in the description of the tails and the skewness of these distributions. The fit of the normal curves is not bad, however, and in all probability no serious error would be made

in the use of them for the determination of the corrections to be applied to the correlations from double-selected data as was done by Rietz.

THE CORRELATION OF JERSEY 8 MONTHS MILK PRODUCTION WITH THE AGE AT TEST.

Common knowledge among dairymen is that milk production and age at the commencement of the lactation are correlated in such a way that advancing age means increased production. The opinion is general that this increase is a linear one.

TABLE 3.

Correlation Surface for Pounds of Milk and Age at Test for Jersey Cattle.
(Lactation Period 8 Months).

	1000–1500	1500–2000	2000–2500	2500–3000	3000–3500	3500–4000	4000–4500	4500–5000	5000–5500	5500–6000	6000–6500	6500–7000	7000–7500	7500–8000	8000–8500	8500–9000	9000–9500	9500–10000	10000–10500	10500–11000	Total
1:6– 2:0				5	15	10	2	2													34
2:0– 2:6	1		4	19	54	51	56	42	19	7	2										255
2:6– 3:0			1	4	6	7	11	12	4	4											49
3:0– 3:6				4	21	22	33	30	20	13	8	3	2								156
3:6– 4:0			3	3	6	9	14	19	16	8	7	3	5	2	1						96
4:0– 4:6				2	8	15	31	24	25	15	7	8	1	2		1					139
4:6– 5:0					7	11	13	20	24	13	8	3	5	3	1						108
5:0– 5:6					7	13	16	14	23	10	5	7	9	2	1	1					108
5:6– 6:0					5	13	12	19	17	15	14	9	4	3	3				1		115
6:0– 6:6				2	2	10	14	8	14	12	12	5	6	3	3			1			92
6:6– 7:0					4	6	9	15	15	12	16	8	7	4	1		2		1		100
7:0– 7:6			2	1	4	5	16	11	19	7	6	5	5	2							83
7:6– 8:0					3	11	8	9	9	14	14	9	5	1	3	1					87
8:0– 8:6				1	7	7	7	10	15	8	7	4	2	1	1				1		71
8:6– 9:0					2	8	8	3	12	7	6	5	3	1				1			56
9:0– 9:6			1	3	4	3	7	9	7		3	5	1								43
9:6–10:0			1	3	1	3	4	6	8	5	5	3	1	1	1						42
10:0–10:6					1	1	3	9	6	1	1	4									26
10:6–11:0			1		3	3	2	2	4	3	3	1	1	1							24
11:0–11:6				1	3	2	6	5	3	4	1		1								26
11:6–12:0							2	1	1		1										5
12:0–12:6				1	3			2	1	2											9
12:6–13:0						1	2	1	2	1											7
13:0–13:6				1		1	1		1	1											5
13:6–14:0							1				1										2
14:0–14:6								1	1												2
14:6–15:0																					
15:0–15:6							1														1
15:6–16:0																					
Total	1		13	50	166	212	279	274	266	162	127	82	58	26	15	3	2	2	3		1741

This opinion has been shown to be erroneous by previous work of this laboratory on the statistics of the 7 day records of American Jersey cattle found in "Jersey sires with their tested daughters," published by the American Jersey Cattle Club. In this work seven day milk production is shown to be a logarithmic curve and not a straight line.

It remains to be shown that this same type of curve describes a true random sample of the Jersey breed for a longer milk period. Data of this sort are important for several reasons chief among which, both practically and theoretically, is the necessity of having suitable correction factors for age to allow comparison of milk records at different periods in the lives of different cows. Toward the solution of this problem the following facts are necessary; what correlation exists between age and milk production; is this correlation sufficient so that it must be taken into account in considering records of different cows at different ages; what is the equation of the regression line between these two variables. Table 3 furnishes the data necessary for this study.

The correlation and its accompanying constants for these two variables are shown in Table 4.

TABLE 4.

Constants Measuring the Association between Amount of Eight Months Milk Produced and Age at Test of Jersey Cows.

r	η	$\eta - r$	$\eta^2 - r^2$
$0.2596 \pm .0151$	$0.4283 \pm .0132$	$0.1689 \pm .0201$	$0.1161 \pm .0108$

This table makes clear several facts concerning the influence of age on milk production. The correlation of $+0.2596 \pm .0151$ shows that age at test and milk production are significantly correlated variates. Taken in conjunction with the correlation ratio it shows clearly that age of the cow at commencement of test must be considered in comparing the records of different cows if the conclusion from the comparison is to be valid. The value of the correlation ratio $+0.4283 \pm .0132$ is considerably

higher than the correlation coefficient. This difference is shown to be highly significant by the value of $\eta - r$ $+0.1689 \pm .0201$. It is altogether probable therefore that the regression of age on milk production is a skew regression. This is shown to be a fact by the constant to measure such skewness. $\eta^2 - r^2$ $0.1161 \pm .0108$ is about 11 times its probable error. The regression is therefore known to be skew. Since this is true the correlation ratio is a better measure of the true correlation than is the correlation coefficient. The relation of age at test is then doubly significant in any comparison of the records of two cows. The regression having been shown to be skew it becomes necessary to deal with it separately.

TYPE OF THE REGRESSION OF MILK PRODUCTION ON AGE OF JERSEY CATTLE.

The means for each array of age have been calculated.

From these means the theoretical curve conforming to the general logarithmic type has been calculated by the method of least squares. The equation to this curve is

$$y = 3387.912 - 99.883x - .487x^2 + 2896.219 \ Log \ x$$

where x is taken in six months intervals from an origin at 1 year and 3 months.

The observations at the higher ages vary a good deal as they are based on small numbers. The theoretical curve strikes through them quite accurately when the unevenness of the observed curve is considered. When we calculate the χ^2 by the method of Slutsky we find that 5 observations contribute a sum of 28.80 to the total of 45.41. These observations are at ages 2 years 9 months, 3 years 3 months, 6 years 9 months, 7 years 9 months and 9 years 3 months. If we measure the fit by the total χ^2 45.41 it is poor. Considering the above mentioned five observations in connection with the other observations it is seen that two of them are plus and three are minus quantities. Not only that but they come at places in the curve so that they would practically counteract each other if the first smoothed curve were used as the observational. It seems altogether reasonable

therefore to consider the fit of this curve measured by a χ^2 somewhat more than 17.00 or what would correspond to the P of a very good fit.

The equation of the curve has many practical uses aside from its interest in a scientific sense. By its use the records of cows at different ages may be brought to the same basis for comparison whether it be for milk inheritance studies, analysis of judging experiments or the like. The time of the theoretical maximum of milk production may be easily calculated from it by differentiation. This maximum is shown to be 7 years 2.4 months a figure considerably above the age customarily called mature form. Further the curve shows that the method used in advanced registry work of determining the amount a Jersey cow should produce for the Register of Merit is falacious in that it is a linear method and does not recognize this logarithmic nature of milk production. In a previous paper the average fat per cent of Jersey cows is given as 5.12. Assuming this figure and dividing the pounds of butter-fat by it gives us the average requirement for milk production in one year. Supposing that ¾ of the year's records is made in the first 8 months of lactation (a figure reasonably close to the expected (Pearl 1915) the required production is found to be 3600 pounds at 2 years and 5200 pounds at 5 years.

Causally considered the logarithmic nature of milk production is of a good deal of interest. The work of a number of students of growth, beginning with Minot's notable studies on rabbits have shown that the phenomena of growth is also a logarithmic function of age. This law appears of wide general application as the work of Lewenz and Pearson have shown it holds for growth in children; Donaldson, Hatai and Jackson have shown it is of general application to the growth of certain organs in the white rat and Pearl and Surface have shown it true for ceratophyllum and corn. It seems, therefore, altogether likely that the mammary glands of the cow also follows this rule. Should this prove true the increase of milk production with age seems of much significance in paralleling these growth phenomena. This paralleling of the two functions would, in fact, seem to indicate causal relation between the two in that the increase in milk production may depend chiefly on the increase in actual mass of the mammary gland due to growth of

this organ and not due to any relative increase in the ability of the cells to secrete more milk.

In a Bulletin to follow this, the relation of the milk yield for one lactation in comparison with that of another subsequent lactation will be analyzed for the same data as presented here.

BULLETIN 287

SELF STERILITY AND CROSS STERILITY IN THE APPLE.[1]

John W. Gowen.

SUMMARY

The results herein presented show that every apple grower should provide suitable varieties for pollinators if large dependable crops are to be secured.

The results presented in Tables 1 and 2 show the apple varieties which will self fertilize. No difference is noted in the fruit set when a variety is self pollinated, when it is pollinated with the pollen from different flowers on the same tree, or when it is pollinated with pollen from different trees of the same variety.

A large amount of sterility is observed in the different varieties. Out of 119 varieties only 42 set fruit, and of that 42 only 15 had a set of fruit which was even moderately commercially profitable.

Tables 3 and 4 show the results of cross pollinations within the apple. Most varieties are capable of ready cross fertilization with the pollen of other varieties. Over 3/4 of those varieties pollinated with pollen of other varieties set fruit satisfactorily.

Results are presented to show that it is necessary to test a variety for cross compatibility before any conclusion can be drawn for the variety.

As pointed out the yield of orchards made up of one block of self sterile trees may be materially increased by the introduction of other varieties.

The size, color, and quality of the fruit is shown to remain practically the same as the standard for the mother parent.

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[1]Papers from the Biological Laboratory, Maine Agricultural Experiment Station, No. 133.

The number of good seeds in the crossed apples is greater than in those which are selfed.

The causes of self sterility in the apple are external and internal. The external, weather, spraying, insects, and disease, are somewhat within the control of the grower.

The chief internal cause of sterility is the slowness of growth of the pollen tube in the selfed style as against that in the crossed style.

Aside from the environmental factors, weather conditions at the blooming period, etc., there is an inborn tendency of certain plants not to produce fruit when fertilized by their own pollen or the pollen of certain varieties within their own species or different species. Among the plants with a well marked tendency in this direction of self sterility and cross sterility is the apple. The tendency of certain of the more common varieties of this species is apparently quite distinct and well marked, within other varieties the trees seem to self fertilize readily with their own pollen. It is of especial importance to the practical grower here in Maine to know what varieties are self fertile and what varieties should have other varieties near by so that the necessary crossing may take place. It is further of importance to know what varieties of those that must be crossed to produce a fair yield, should be planted together so that the best yield and quality of fruit may be obtained. A large amount of time has been devoted to the solution of this problem by the staff of the Biological Laboratory of the Maine Station.

MATERIALS AND METHODS.

The apple orchards and scattering apple trees of Highmoor Farm total to approximately 3000 trees. When the grafts are included there are about 25 different varieties represented within this group of 3000 trees. The experiments herein described include 16 of these varieties. Controlled crosses have been made between these varieties. The apples resulting from these crosses were measured. The number of good seed and the number of poor seed were determined for each cross. The germination of these seeds when planted out doors in a cold frame

was recorded in connection with the data on transplantation. These data all bear on the problem of self sterility and cross sterility in the apple and will be used in connection with this study. The publication of the results obtained from the crosses, the bearing ability of the seedling trees, and the quality of the resulting apples will form the basis of other reports on the orchard work of the Biological Laboratory.

The sterility tests are made in four ways. To test for self sterility the unopen buds are inclosed in a ten pound paper bag. These bagged flowers are treated in two ways; (a) the bags are left undisturbed until the fruit is set; (b) the bags are opened at the height of the bloom and the pollen from the anthers brushed over onto the stigmas, the bags replaced and left until the fruit is set.

The tests for cross sterility are likewise made in two ways; sterility between members of the same variety and sterility between different varieties. All of this was done with emasculated flowers, the pollen transfers being made with camel's hair brushes. In each case the flowers, both emasculated and pollinated were covered with paper bags, care being used in the removal for pollination and subsequent replacing of the paper bag to prevent accidental pollination.

When the fruit is set the paper bags used in the pollination work are replaced with cheese cloth bags. All the crosses made are tagged with a distinctive number to prevent any pedigree errors.

Self Sterility and Self Fertility.

In table 1 are shown the result of the crosses involving the pollen from a flower cluster being placed on the pistils of that same flower cluster or a different flower cluster of the same trees or different trees. The flower clusters which are only bagged depend, of course, on chance agencies to transport the pollen from the anthers to the stigmas. Those flowers which have the pollen transferred from the anthers of the flower cluster to the stigmas of the same flower cluster by means of the camel's hair brush brushing the pollen across from the one to the other eliminate this chance element. The average number of flowers worked to each flower cluster was six. The results

as given in table 1 are all for clusters which did or did not develop fruit. If it is desired to determine the fruit which set per flower the results should be multiplied by this number to obtain the number of fruit buds worked.

The selfings which matured apples are the only ones which are recorded as successful. Many of those which fall in the unsuccessful group did start to develop and some even remained after the June drop for a short time. These are not recorded, however, since this paper deals with this problem chiefly from the viewpoint of the mature, marketable fruit.

TABLE 1.

Fertility of the Ovule to Pollen Within the Same Variety.

METHOD OF POLLEN APPLICATION.

Variety	Flower cluster bagged and left		Pollinated with pollen of same tree		Pollinated with the pollen of a different tree but same variety	
	Fruit matured	No Fruit	Fruit matured	No Fruit	Fruit matured	No Fruit
Baldwin	2	11	3	22		2
Ben Davis		65		229		26
Crab		3		8		
Duchess			1*	3		
Early Harvest		6		7		
Golden Russett		15		46		6
Hurlbert Sweet		5		10		
McIntosh Red		16		12		
Northern Spy		1		34	1*	3
Red Astrachan				4		
Rhode Island Greening		2		10		2
Wealthy	1					

*These apples were very poor specimens from which no seeds germinated. The seeds themselves were shrunken and shriveled.

From this table it is clear that most varieties of apples show more or less pronounced self sterility. Within the twelve varieties under consideration only four showed any fertility to their own pollen. For those which showed such fertility the Wealthy was self fertile once, the Duchess was doubtfully self fertile in one out of four trees; the Baldwin was self fertile in five out of forty crosses and the Northern Spy was doubtfully self fertile in one out of thirty-nine trials. It is clear from these results that the proportion of the flowers which are self fertile to their

own pollen is slight even with those varieties which will self fertilize. This is especially true when it is realized that each of the selfings within table 1 represent the flower cluster and not individual flowers.

The results from the different methods of pollination are chiefly negative in character. The three different groups show no material difference in the set of the fruit for the three methods. This is of interest in connection with the results of pollination with pollen of the same tree and the results of pollination with pollen of a different tree but of the same variety. The results are in each case approximately the same. This would be expected in view of the probable fact that the trees of a given variety are ultimately of the same origin, coming as they do from the same original seedling. Such results indicate the relative stability of the buds and the trees which grow from them in their presumably hereditary behavior to crossing with different kinds of pollen.

It shows further the probability that the planting of a large block of trees of the same variety, if it is self sterile, will not tend to a larger crop of fruit because for these self sterile varieties the pollen of other trees of the same variety is no more compatible than the pollen of the tree itself when applied to the stigmas.

It is of considerable interest to gather together the results on the self sterility of the apples varieties as it has been determined by the different states, both to determine on as large numbers as possible the amount of sterility which exists and also to see whether the technique or climatic conditions of one state favor the fruiting of varieties normally incompatible to their own pollen in other climates. For this purpose the results on self sterility of the different varieties have been collected and brought together in table 2.

TABLE 2.

Self Fertility and Self Sterility in the Varieties of the Apple.

Variety	Number selfed	Number fruit matured	Number fruit not matured
Arkansas Black[4]	100		100
Autumn Sweet[4]	50		50
Baldwin[1]	169	1	168

Self Fertility and Self Sterility in the Varieties of the Apple. —Continued.

Variety	Number selfed	Number fruit matured	Number fruit not matured
Baldwin	40	5	35
Baldwin[4]	200	14	186
Bailey's Sweet[4]	100	23	77
Ben Davis[4]	100	3	97
Ben Davis[13]	472	11	461
Ben Davis	320		320
Ben Davis	19		19
Bethlehemite[4]	50	10	40
Bietigheimer[4]	50		50
Bellflower (Yellow)[4]	50		50
Bottle Greening[4]	50		50
Bough, Sweet[2]	225	55	170
Canada Red[4]	50	1	49
Canada Reinette[4]	50		50
Canada Sweet[4]	50		50
Colvert[4]	100	7	93
Crab	11		11
Delaware[4]	100		100
Domine[4]	100		100
Duchess	4	1?	3
Dutch Mignonne[4]	50		50
Early Harvest	13		13
Early Harvest[2]	408	24	384
Early Ripe[2]	150		150
Early Strawberry[4]	50		50
English Russett[2]	100		100
Esopus (Spitzenburg)[1]	86	1	85
Ewalt[4]	100		100
Fallwine[4]	100	23	77
Fallawater[4]	100		100
Fall Jenneting[4]	100	3	97
Fameuse[1]	223	1	222
Fanny[2]	150		150
Gano[4]	50		50
Gilpin (Carthouse)[2]	215	7	208
Golden Russett	67		67
Golden Sweet[4]	100		100
Gravenstein[2]	95		95
Gravenstein[4]	50		50
Great Bearer[4]	100		100
Green Sweet[4]	100		100
Grimes Golden[4]	100	14	86
Grimes[13]	442	37	405
Grimes[2]	135		135
Haas[4]	100		100
Hanwell Souring[4]	50		50
Hawley	53		53
Holland Beauty[4]	50		50
Holland Pippin[4]	100		100
Hoover's Red[4]	50		50
Hurlbert Sweet	15		15
Hydes Keeper[4]	50		50
Jonathan[13]	452	17	435
Jonathan[4]	200		200
Jewett's Red[4]	50	3	47
July, Fourth of[2]	110	26	84
King	15		15
King of Tompkins Co.[4]	100		100
Keswick Codlin[4]	50	40	10
Longfellow[4]	100	27	73
Limbertwig[4]	100		100
Lily of Kent[2]	130		130
Lily of Kent[3]	116		116
Maiden's Blush[4]	100		100
Mann[4]	100	2	98
Mammoth Black Twig[4]	100		100
May[4]	100		100
McMahon White[4]	100		100

Self Fertility and Self Sterility in the Varieties of the Apple. —Continued.

Variety	Number selfed	Number fruit matured	Number fruit not matured
McIntosh Red	28		28
Melon[4]	50		50
Melon Sweet[4]	50		50
Missouri Pippin[4]	50		50
Missouri Pippin[3]	57		57
Missouri Pippin[2]	150		150
Montreal Beauty (crab)[4]	100		100
Munson Sweet[4]	50		50
Nero[2]	150		150
Newtown[4]	100	66	84
Northern Spy	38	1?	37
Northern Spy[1]	19		19
Northern Sweet[1]	113		113
Oldenburg[4]	100	5	95
Ortley[4]	100		100
Paradise Sweet[4]	100		100
Paragon[3]	195		195
Paragon[2]	180		180
Pewaukee[4]	50		50
Porter[1]	52		52
Pryor's Red[4]	50	2	48
Pumkin Russett[4]	100	16	84
Astrachan[2]	200	12	188
Ralls[4]	100		100
Rambo[4]	100	2	98
Red Astrachan	4		4
Red Astrachan[1]	16		16
Red Canada[1]	80		80
Red Cheek Pippin[4]	100		100
Red Golden Pippin[4]	50		50
Rhode Island Greening	14		14
Rhode Island Greening[4]	100		100
Rhode Island Greening[1]	703		703
Romanite[4]	100		100
Rome Beauty[4]	100		100
Roseau[1]	120		120
Roxbury (Russett)[1]	119		119
Salome[4]	100		100
Scott's Winter[4]	100	39	61
Shiawassee[4]	100	23	77
Spitzenburg[4]	100	7	93
Stark[4]	100	1	99
Stark[2]	150		150
Stayman[3]	161		161
Stayman[2]	106		106
Steel's Red[4]	50		50
Strawberry[2]	200	1	199
Red Streak[2]	200	1	199
St. Lawrence[4]	100		100
Summer Permain[4]	50		50
Summer Queen[4]	100		100
Sweet Bough[4]	50		50
Tolman (Sweet)[1]	223		223
Tolman Sweet[4]	100		100
Transcendent Crab[4]	100		100
Trumble Sweet[4]	100		100
Twenty Ounce[4]	100		100
Wealthy	1	1	
Wagener[4]	50	3	47
Washington[4]	50	7	43
Wealthy[1]	28		28
Wealthy[4]	50		50
Westfield (Seek-no-further)[1]	485		485
Western Beauty[4]	50		50
Williams (Favorite)[1]	63		63
Williams Favorite[2]	150		150
Willow Twig[4]	50	2	48
Winesap[4]	100		100

Self Fertility and Self Sterility in the Varieties of the Apple. —Concluded.

Variety	Number selfed	Number fruit matured	Number fruit not matured
Winesap[2]	300		300
Winesap[13]	550	2	548
White Pippin[4]	100	26	74
Whitney's Crab[4]	100	4	96
Yellow Transparent[2]	363	20	343
Yellow Transparent[4]	25	2	23
York Imperial[4]	100		100
York Imperial[3]	134	1?	133

Even a cursory examination of this table will show that the degree of self fertility in the apple is quite generally insignificant. Within this group of one hundred and nineteen varieties only 42 or less than half are known to have self-fertilized and set fruit. Of these 42 varieties only 15 set fruit in any numbers, the rest had only one or two fruit which matured representing something less than five per cent of the total number of crosses made.

Table 2 shows one of the best commercial varieties, the Baldwin to be self fertile in Maine and elsewhere. Of the other leading commercial varieties Rhode Island Greening, Golden Russett, Tolman Sweet, Twenty Ounce, McIntosh and Gravenstein proved to be self sterile in all tests. The varieties Northern Spy, Esopus Spitzenburg, Ben Davis, Fameuse and Oldenburg proved very slightly fertile. Of the other commercial varieties which proved somewhat more fertile might be mentioned the Jonathan, Early Harvest and Yellow Transparent.

Considerable difference is evidenced by the record of the set of fruit of a variety within the different states. The Baldwin sets a very limited number of fruit in Vermont whereas in Maine and Oregon its set of fruit was more numerous. The Ben Davis in Maine and Vermont set no fruit whereas in Arkansas and Oregon it set a limited number of apples. The Red Astrachan proved self sterile in Maine and Vermont but with a test made in Maryland set fruit on self fertilization. These results make it seem probable that the environmental conditions of the different states affect the self fertility of these differently. Caution is consequently necessary in applying the results of one state to that of another.

CROSS FERTILITY AND CROSS STERILITY IN THE APPLE.

In table 3 are shown the results of crossing one variety with the pollen of another variety. The first column records the female variety and the second column the pollen variety. In the column marked "Successful pollination" are recorded the number of pollinations which produced mature apples. In the column "Unsuccessful pollination" are recorded the number of flower clusters emasculated and pollinated.

TABLE 3.

Cross Fertility and Cross Sterility in the Apple.

Female Parent	Pollen Parent	Successful Pollination	Unsuccessful Pollination
Ben Davis	Baldwin	1*	11
Duchess	Baldwin		20
Golden Russett	Baldwin		2
Northern Spy	Baldwin	1†	12
Red Astrachan	Baldwin		4
Rhode Island Greening	Baldwin		2
Baldwin	Ben Davis		4
Golden Russett	Ben Davis	5	9
Hurlbert Sweet	Ben Davis	3	7
McIntosh Red	Ben Davis		5
Northern Spy	Ben Davis		2
Rhode Island Greening	Ben Davis		2
Ben Davis	Canada Red	5	18
Hurlbert Sweet	Canada Red	1	1
Ben Davis	Crab	9	4
Early Harvest	Crab		7
Baldwin	Duchess	1	9
Early Harvest	Duchess	1	1
Red Astrachan	Duchess	1	1
Baldwin	Golden Russett	22	5
Ben Davis	Golden Russett	5	40
Northern Spy	Golden Russett		2
Red Astrachan	Golden Russett		2
Rhode Island Greening	Golden Russett		2
Ben Davis	Gravenstein	3	22
Ben Davis	Hurlbert Sweet		11
Early Harvest	Hurlbert Sweet		2
Ben Davis	McIntosh Red	40	19
Duchess	McIntosh Red		4
Early Harvest	McIntosh Red		2
Hurlbert Sweet	McIntosh Red		4
Baldwin	Northern Spy		2
Ben Davis	Northern Spy	10	10
Golden Russett	Northern Spy	3	23
Ben Davis	Opalescent	19	23
Hurlbert Sweet	Opalescent		5
McIntosh Red	Opalescent	2	12
Baldwin	Rhode Island Greening		2
Ben Davis	Rhode Island Greening		2
Golden Russett	Rhode Island Greening		2
Northern Spy	Rhode Island Greening		2
Ben Davis	St. Lawrence	3	9
Ben Davis	Wealthy	9	3

*Not found until succeeding year when seeds were no good.
†Had six shrivelled seeds.

Forty-three different kinds of crosses were tried in testing for any cross sterility which might exist between the different varieties. Of these crosses 20 proved compatible and formed fruit. Only two of the crosses tried more than 10 times failed to set fruit. These two crosses were Duchess female x Baldwin pollen and Ben Davis female x Hurlbert Sweet pollen. When the cross was made the other way Baldwin female x Duchess pollen and Hurlbert Sweet female x Ben Davis pollen the cross was successful and fruit was matured. It is desirable, therefore, to leave those crosses which did not set fruit in abeyance until such time as more data can be collected for them before any definite conclusion is drawn on their cross sterility under Maine conditions.

Of those trees which proved fertile certain varieties stand out as quite desirable for commercial plantings. Considering the number of crosses made in conjunction with the amount of fruit set Ben Davis pollen proved quite successful with Golden Russett female; Golden Russett pollen proved to set a high percentage of the fruit when crossed with the Baldwin; Golden Russett pollen crossed fairly well with the Ben Davis; McIntosh Red pollen proved very desirable for crossing on Ben Davis female. The same was also true for the pollen of Northern Spy, Opalescent, Crab and Wealthy when crossed with Ben Davis.

Table 4 gives the same data for the varieties which have been tested for cross fertility as that given in table 2 for the self sterile varieties. The data are presented for those which are compatible and set fruit on crossing and those which did not prove compatible and did not form fruit. The crosses which are marked plus (+) or yes proved to set fruit on crossing. Those marked minus (—) did not set fruit. After those which did not set fruit is given the number of trials that were made for the given cross. From these data some estimate may be made of the probability that fruit might be set on a further crossing of these same varieties.

The percentage of fruit set or the degree of compatibility of the cross is indicated where it is known by the number of plus signs. The ± sign represents a very low percentage of fruit set with only a few number of trials. The + sign shows that a low percentage of fruit was set, the number of trials be-

ing large. The ++ sign shows a greater percentage of fruit set. The +++ sign indicates a cross which proved highly compatible by the percentage of fruit which resulted from the cross.

As these data represent the crosses which have been made in several states it gives an opportunity to compare the fruit set of the same cross under the different environmental conditions.

TABLE 4.

Cross Fertility in the Apple.

Variety	Pollen	Fruit Set	No. of Trials
Arkansas Black[14]	x Jonathan	yes	
Baldwin	x Ben Davis	—	4
Baldwin	x Duchess	+	
Baldwin	x Golden Russett	+++	
Baldwin	x Northern Spy	—	2
Baldwin	x Rhode Island Greening	—	2
Ben Davis	x Baldwin	+	
Ben Davis	x Canada Red	+	
Ben Davis	x Crab	+++	
Ben Davis[6]	x Esopus	yes	
Ben Davis	x Golden Russett	+	
Ben Davis	x Gravenstein	+	
Ben Davis[6]	x Green Newton	yes	
Ben Davis[13]	x Grimes	++	
Ben Davis	x Hurlbert Sweet	—	11
Ben Davis[13]	x Jonathan	+	
Ben Davis[6]	x Jonathan	yes	
Ben Davis[14]	x Jonathan	yes	
Ben Davis[6]	x McIntosh	yes	
Ben Davis	x McIntosh Red	+++	
Ben Davis[6]	x Mother	yes	
Ben Davis[14]	x Newtown	yes	
Ben Davis	x Northern Spy	++	
Ben Davis	x Opalescent	++	
Ben Davis	x Rhode Island Greening	—	2
Ben Davis[14]	x Rome	yes	
Ben Davis[14]	x Spitzenburg	yes	
Ben Davis	x St. Lawrence	+	
Ben Davis[14]	x Wagener	yes	
Ben Davis	x Wealthy	+++	
Ben Davis[13]	x Winesap	±	
Black Ben Davis[11]	x Hydes Keeper	yes	
Black Ben Davis[11]	x Willow Twig	yes	
Blenhein Orange[11]	x Hanwell Souring	yes	
Blenhein Orange[11]	x Arkansas Black	yes	
Blenhein Orange[11]	x Jonathan	yes	
Bloomfield[8]	x Delicious	+++	
Bloomfield[8]	x Oldenburg	+	
Bottle Greening[11]	x Pewaukee	yes	
Bottle Greening[11]	x Charlottenthaler	yes	
Delicious[8]	x Grimes	—	64
Delicious[14]	x Jonathan	yes	
Duchess	x Baldwin	—	20
Duchess	x McIntosh Red	—	4
Early Harvest	x Crab	—	7
Early Harvest	x Duchess	+	
Early Harvest[8]	x Early Ripe	±	
Early Harvest	x Hurlbert Sweet	—	2
Early Harvest	x McIntosh Red	—	2

Cross Fertility in the Apple.—Continued.

Variety	Pollen	Fruit Set	No. of Trials
Early Harvest[8]	x Red June	±	
Early Harvest[8]	x Williams	+	
Early Harvest[8]	x Yellow Transparent	±	
Early Ripe[8]	x Chenango	—	180
Early Ripe[8]	x Early Harvest	++	
Early Ripe[8]	x Kinnard	—	42
Early Ripe[8]	x Red Astrachan	+	
Early Ripe[8]	x Red June	+	
Early Ripe[7]	x Red June	++	
Early Ripe[8]	x Stayman	+	
Early Ripe[8]	x Williams	++	
Early Ripe[8]	x Yellow Transparent	++	
Early Ripe[7]	x Yellow Transparent	+	
Esopus[6]	x Ben Davis	yes	
Esopus[6]	x Jonathan	yes	
Golden Russett	x Baldwin	—	2
Golden Russett	x Ben Davis	++	
Golden Russett	x Northern Spy	+	
Golden Russett	x Rhode Island Greening	—	2
Gravenstein[8]	x Doucin	++	
Gravenstein[14]	x Jonathan	yes	
Gravenstein[14]	x Newtown	yes	
Grimes[8]	x Akin	++	
Grimes[13]	x Ben Davis	++	
Grimes[8]	x Early Ripe	±	
Grimes[13]	x Jonathan	++	
Grimes Golden[11]	x Twenty Ounce	yes	
Grimes[8]	x Stayman	+	
Grimes[13]	x Winesap	+	
Hanwell Souring[11]	x Montreal Beauty	yes	
Hanwell Souring[11]	x Charlottenthaler	yes	
Hoover's Red[11]	x Fallwine	yes	
Hoover's Red[11]	x Pewaukee	yes	
Hoover's Red[11]	x Maiden's Blush	yes	
Hurlbert Sweet	x Ben Davis	++	
Hurlbert Sweet	x Canada Red	+	
Hurlbert Sweet	x Opalescent	—	5
Hurlbert Sweet	x McIntosh Red	—	5
Hyde's Keeper[11]	x Tolman Sweet	yes	
Ingram[8]	x Rome	—	52
Ingram[8]	x Stayman	—	242
Jonathan[14]	x Arkansas Black	yes	
Jonathan[11]	x Ben Davis	yes	
Jonathan[14]	x Ben Davis	yes	
Jonathan[13]	x Ben Davis	+	
Jonathan[13]	x Grimes	+	
Jonathan[14]	x Rome	yes	
Jonathan[11]	x Spitzenburg	yes	
Jonathan[14]	x Spitzenburg	yes	
Jonathan[14]	x Wagener	yes	
Jonathan[13]	x Winesap	+	
Jonathan[14]	x Newtown	yes	
Jonathan[11]	x Yellow Newtown	yes	
Keswick Codlin[11]	x Bottle Greening	yes	
Keswick Codlin[11]	x Lady Apple	yes	
Lily of Kent[5]	x Paragon	—	53
Limbertwig[11]	x Hoover's Red	yes	
Limbertwig[11]	x Arkansas Black	yes	
Maiden's Blush[11]	x York Imperial	yes	
Mammoth Black Twig[11]	x Mann	yes	
Mammoth Black Twig[11]	x Red Astrachan	yes	
Mammoth Black Twig[11]	x Charlottenthaler	yes	
Mammoth Black Twig[11]	x Hanwell Souring	yes	
Mann[11]	x Shiawassee	yes	
Mann[11]	x Haas	yes	
Mann[11]	x Pumpkin Russett	yes	
McIntosh Red	x Ben Davis	—	5
McIntosh Red[6]	x Lawver	yes	
McIntosh Red	x Opalescent	+	
Missouri Pippin[3]	x York Imperial	+	
Mother[8]	x Bonnum	++	

Cross Fertility in the Apple.—Continued.

Variety	Pollen	Fruit Set	No. of Trials
Mother[8]	x Stayman	+	
Newtown[10]	x White Pippin	+++	
Newtown[10]	x Grimes Golden	+++	
Newtown[10]	x Jonathan	+++	
Newtown[10]	x Ben Davis	+++	
Newtown[10]	x Spitzenburg	+++	
Newtown[14]	x Spitzenburg	yes	
Newtown[14]	x Wagener	yes	
Newtown[10]	x White Bellflower	+++	
Nickajack[8]	x Stayman	—	371
Northern Spy	x Baldwin	+	
Northern Spy	x Ben Davis	—	2
Northern Spy	x Golden Russett	—	2
Northern Spy	x Rhode Island Greening	—	2
Oliver[8]	x Akin	+	
Ortley[11]	x Haas	yes	
Paragon[8]	x Bloomfield	—	60
Paragon[12]	x Lily of Kent	—	46
Paragon[5]	x Lily of Kent	+	
Paragon[12]	x Stayman	±?	
Paragon[3]	x Stayman	—	157
Paragon[5]	x Stayman	—	25
Paragon[12]	x Winesap	—	157
Pewaukee[11]	x Hoover's Red	yes	
Pewaukee[11]	x Arkansas Black	yes	
Pewaukee[11]	x Fallwine	yes	
Pewaukee[11]	x Hanwell Souring	yes	
Ralls[6]	x Northern Spy	yes	
Red Astrachan	x Baldwin	—	4
Red Astrachan	x Duchess	+	
Red Astrachan	x Golden Russett	—	2
Red June[8]	x Early Harvest	++	
Red June[8]	x Early Ripe	+	
Red June[7]	x Early Ripe	++	
Red June[8]	x Grimes	—	35
Red June[8]	x Williams	+	
Red June[8]	x Yellow Transparent	++	
Red June[7]	x Yellow Transparent	++	
Rhode Island Greening	x Baldwin	—	2
Rhode Island Greening	x Ben Davis	—	2
Rhode Island Greening	x Golden Russett	—	2
Rome[8]	x Akin	—	47
Rome[14]	x Ben Davis	yes	
Rome[14]	x Newtown	yes	
Rome[6]	x Northern Spy	yes	
Rome[14]	x Spitzenburg	yes	
Rome[8]	x Stayman	—	604
Rome[14]	x Wagener	yes	
Shiawassee[11]	x Early Strawberry	yes	
Shiawassee[11]	x Sweet Bough	yes	
Shiawassee[11]	x Tetofsky	yes	
Shiawassee B[9]	x Arkansas Black	+++	
Shiawassee C[9]	x Arkansas Black	+++	
Spitzenburg A[9]	x Baldwin	+++	
Spitzenburg[14]	x Ben Davis	yes	
Spitzenburg[14]	x Jonathan	yes	
Spitzenburg F[9]	x Jonathan	+++	
Spitzenburg[14]	x Newtown	yes	
Spitzenburg E[9]	x Newtown	+++	
Spitzenburg A[9]	x Newtown	+++	
Spitzenburg B[9]	x Ortley	+++	
Spitzenburg D[9]	x Red Cheek Pippin	+++	
Spitzenburg[14]	x Rome	yes	
Spitzenburg[14]	x Wagener	yes	
Stark[8]	x Red Astrachan	—	84
Stayman[8]	x Bonnum	+	
Stayman[8]	x Delicious	+	
Stayman[8]	x Doucin	—	40
Stayman[8]	x Early Ripe	+	
Stayman[8]	x Gravenstein	—	300
Stayman[8]	x Grimes	+	

Cross Fertility in the Apple.—Concluded.

Variety	Pollen	Fruit Set	No. of Trials
Stayman[5]	x Lily of Kent	—	20
Stayman[12]	x Lily of Kent	—	11
Stayman[3]	x Missouri Pippin	—	158
Stayman[7]	x Nickajack	+	
Stayman[8]	x Nickajack	++	
Stayman[5]	x Paragon	—	52
Stayman[3]	x Paragon	—	157
Stayman[12]	x Paragon	—	66
Stayman[8]	x Williams	++	
Stayman[12]	x Winesap	—	33
Stayman[3]	x York Imperial	+?	
Stayman[8]	x Yellow Transparent	—	10
Steele's Red[11]	x Pumpkin Russett	yes	
Steele's Red[11]	x Hoover's Red	yes	
Steele's Red[11]	x Yellow Newtown	yes	
Summer Permain[11]	x Salome	yes	
Summer Permain[11]	x Hanwell Souring	yes	
Sutton[6]	x Northern Spy	yes	
Tetofsky[11]	x Mann	yes	
Tetofsky[11]	x Haas	yes	
Wagener[14]	x Ben Davis	yes	
Wagener[14]	x Jonathan	yes	
Wagener[14]	x Rome	yes	
Wagener[14]	x Spitzenburg	yes	
Washington[11]	x Oldenburg	yes	
Washington[11]	x Hyde's Keeper	yes	
Washington[11]	x Charlottenthaler	yes	
Williams[8]	x Early Ripe	++	
Williams[8]	x Stayman	—	14
Williams[8]	x Yellow Transparent	++	
Winesap[11]	x Arkansas Black	yes	
Winesap[13]	x Ben Davis	+	
Winesap[14]	x Ben Davis	yes	
Winesap[13]	x Grimes	+	
Winesap[13]	x Jonathan	+	
Winesap[5]	x Lily of Kent	—	75
Winesap[12]	x Lily of Kent	—	29
Winesap[12]	x Paragon	—	113
Winesap[5]	x Paragon	—	102
Winesap[5]	x Stayman	+	
Winesap[12]	x Stayman	—	108
Wolf River[6]	x Yellow Transparent	++	
York Imperial[3]	x Missouri Pippin	+++	
Yellow Transparent[7]	x Early Ripe	+	
Yellow Transparent[8]	x Early Ripe	+++	
Yellow Transparent[8]	x Nickajack	+++	
Yellow Transparent[8]	x Oliver	+++	
Yellow Transparent[8]	x Red Astrachan	+++	
Yellow Transparent[8]	x Red June	+++	
Yellow Transparent[8]	x Stark	—	35
Yellow Transparent[8]	x Stayman	—	212
Yellow Transparent[8]	x Williams	+++	

Table 4 shows that of the 243 tests for cross sterility between two varieties 57 are recorded as not producing fruit, 186 as producing fruit of which 90 produced fruit but did not record the number of crosses made to accomplish its production. These figures show that over ¾ of the varieties crossed proved compatible with each other. It will be remembered that nearly ⅔ of those which were self fertilized showed no fruit production. These facts argue strongly for the necessity of arranging

for cross pollination in the commercial production of apples. If the relative set of the fruit is considered it is even more clearly demonstrated that cross pollination is necessary in commercial orcharding for of the 42 self fertilized which did set fruit as shown in table 2, less than 16 set fruit in anything but negligible amounts.

It is of some interest to examine the crosses which did not set fruit a little further to determine if possible the reason why they did not. Out of the 57 which did not prove compatible about half (26) had enough trial crosses made to make it seem likely that these crosses were nearly if not entirely, incompatible. These crosses were Delicious x Grimes, Duchess x Baldwin, Early Ripe x Chenango, Early Ripe x Kinnard, Ingram x Rome, Ingram x Stayman, Lily of Kent x Paragon, Nickajack x Stayman, Paragon x Bloomfield, Paragon x Lily of Kent, Paragon x Stayman, Paragon x Winesap, Red June x Early Ripe, Rome x Akin, Rome x Stayman, Stark x Red Astrachan, Stayman x Doucin, Stayman x Gravenstein, Stayman x Lily of Kent, Stayman x Missouri Pippin, Stayman x Paragon, Stayman x Winesap, Winesap x Lily of Kent, Winesap x Paragon, Yellow Transparent x Stark, and Yellow Transparent x Stayman. It will be noted that the varieties Stayman, Winesap and Paragon form the largest part of these sterile crosses. Stayman is known to be a seedling from the Winesap.* The Paragon is thought to have originated from the Winesap† crossed by Limbertwig. If these facts represent the true state of affairs it is entirely likely that the seedlings would also have the incompatibility of the parents from which they sprang provided, of course, that sterility in the apple is inherited in a similar manner to other known inheritance.

It is of interest to note also that the variety Lily of Kent enters into a number of these crosses. Lily of Kent x Paragon and Paragon x Lily of Kent are reciprocally sterile. Lily of Kent pollen is also sterile with Stayman and Winesap. So, likewise, is the cross between Yellow Transparent x Stayman and Stayman x Yellow Transparent reciprocally sterile. On the other hand the crosses of Nickajack x Stayman and Red June x Early Ripe are sterile but the reciprocal crosses are

*Beach, S. A., et al., 1905 The Apple of New York. vol. I, p. 318.
†Beach, S. A., et al., 1905 The Apple of New York. vol. I, p. 247.

fairly fertile and produce fruit. Crosses, Stayman x Doucin and Stayman x Gravenstein are sterile but the cross Gravenstein x Doucin is fertile. These facts make it clear that because a cross between two varieties (a x b) is sterile it is no guarantee that the reciprocal cross (b x a) will be sterile. Further if the cross of two given varieties (a x b) is sterile and the cross of two varieties including one of the given varieties (a x c) is sterile it is apparently equally possible for the two different varieties entering into the cross (b x c) to be compatible or incompatible.

The varieties which are particularly fertile when crossed are of especial interest to the man who desires to plant a commercial orchard or to increase the bearing ability of one already in existence by top working certain of the trees. Those crosses which are marked with the three pluses (+++) in table 4 should prove heavy bearers when planted together. Such orchards should be planted with the female parent, indicated in the first column, as the predominating tree in the block.

Among the leading varieties in Maine which should form desirable combinations for commercial work are Baldwin with the Golden Russett for the pollen parent; Ben Davis with McIntosh Red, Northern Spy, Opalescent or Wealthy for pollen parent; Golden Russett with Ben Davis for the pollinator. Esopus can be planted with Ben Davis and Jonathan. Newton crosses well with any of the common pollen varieties Grimes Golden, Jonathan, Ben Davis or Spitzenburg. The relative compatibility of the other varieties may be seen by consulting the lists.

The work of Alderman* makes it clear that the differences in the yield of the fruit in self and in cross pollinated orchards occupies about the same relations as are shown in the hand self pollinations of table 2 and the hand cross pollinations of table 4. In this experiment a Rome Beauty* orchard that had been bearing only moderate crops was cross pollinated by bringing in branches of other varieties and allowing the bees to work over these other varieties at the same time that they worked over the Rome Beauty. A suitable control was made with an-

*Alderman, W. H., 1917. Experimental Work on Self-sterility of the Apple. In Proc. Amer. Soc. for Hort. Sci. p. 94-101.

*The Rome Beauty as will be seen in table 2 is nearly if not quite self-sterile.

other block of Rome Beauty trees some distance away. The cross fertilized Rome Beauty trees yielded 174¼ bushels; the check Rome Beauty trees for which no arrangement for cross fertilization was made, yielded 83¼ bushels or the cross fertilized trees had nearly twice the yield of the other check block. The demonstration was made complete by a repetition of the experiment in a succeeding year.

THE GROWTH VIGOR AND RESULTING SIZE OF APPLES FROM SELFED OR CROSSED VARIETIES.

Certain objections may be made to the introduction of cross fertilization on the ground that where such cross fertilization takes place a *scrub* is produced which is worse than either parent. If such is the case it would be the height of folly to cross pollinate even though there was an increased yield, for apples are largely sold on the basis of their color, shape and size, and if these items are not properly developed the increased yield would not make up for the reduced selling price. The data in table 5 present the material to analyze this problem.

TABLE 5.

Size and Number of Seed from Selfed and Crossed Fertilized Apple Blossoms.

Varieties Crossed	No. of Individuals	Mean Diameter in Centimeters	Mean Character of Seed
Female Pollen			
Baldwin x Baldwin	5	6.36	2.8 g — 2.2 p.
Baldwin x Duchess	1	7.00	4.0 g — 3.0 p.
Baldwin x Golden Russett	48	6.36	3.8 g — 2.8 p.
Ben Davis x Canada Red	8	6.65	5.5 g — 1.4 p.
Ben Davis x Crab	12	6.25	4.4 g — 1.4 p.
Ben Davis x Golden Russett	5	5.66	6.2 g — 0.8 p.
Ben Davis x Gravenstein	3	6.53	1.7 g — 0.3 p.
Ben Davis x McIntosh Red	74	6.28	6.2 g — 1.1 p.
Ben Davis x Northern Spy	14	5.22	5.9 g — 0.4 p.
Ben Davis x Opalescent	35	6.38	7.0 g — 0.8 p.
Ben Davis x St. Lawrence	6	6.75	6.1 g — 0.2 p.
Ben Davis x Wealthy	16	4.94	4.3 g — 2.3 p.
Early Harvest x Duchess	2	----	8.0 g — 0.0 p.
Golden Russett x Ben Davis	5	6.22	7.4 g — 1.2 p.
Golden Russett x Northern Spy	3	5.40	7.7 g — 0.0 p.
Hurlbert Sweet x Ben Davis	3	7.17	4.3 g — 3.7 p.
Hurlbert Sweet x Canada Red	1	6.70	3.0 g — 3.0 p.
McIntosh Red x Opalescent	2	6.15	6.5 g — 0.5 p.
Wealthy x Wealthy	1	----	4.0 g — 0.0 p.

Data on the size and number of seeds of the apples resulting from a cross are presented in summary form from appendix table I.

From the data contained in table 5 it is clear that the Baldwin apples resulting from cross pollination were of as good average size as were the apples which resulted from self fertilization. Since the set of fruit from the cross fertilization was larger than from the self fertilization it follows that the profit to the grower was much greater for the blossoms where cross pollination took place than where self pollination was resorted to.

The apples resulting from cross pollination of the Ben Davis were likewise all of good size from the market standpoint, as were also the apples from the other crosses. They carried more good seeds than did the self fertilized apples. From these facts we may conclude that the size of the fruit is favorably affected rather than otherwise by cross pollination.

The amount of this cross pollination affect appears to differ with different varieties. Alderman, W. H.* found that for the Rome Beauty above mentioned the cross pollination by other varieties increased the size (weight) 27.8 per cent over that of the apples resulting from self fertilization. For York Imperial the increased size for cross pollination was 42.7 per cent over the size of the selfed apple. For Wagener the effect of cross fertilization over self fertilization was in the direction of reduced size the reduction being 17.3 per cent. The results of these experiments would seem to show in general a beneficial effect of cross fertilization on size. Some work of Wicks, W. H.† using reciprocal crosses of the Ben Davis, Grimes, Jonathan and Winesap varieties to determine the effect of crossing versus selfing on the resulting color, size and quality of the fruit quite clearly shows that for these items the characters of the Mother parent varieties are found in the resulting fruit irrespective of what pollen parent is used.

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*Alderman, W. H. 1917. Experimental Work on Self-Sterility of the Apple. In Proc. Amer. Soc. for Hort. Sci. p. 94-101.

†Wicks, W. H., 1918. The Effect of Cross Pollination on Size, Color, Shape, and Quality of the Apple. In Bul. 143. Arkansas Agr. Expt. Station.

It is true that certain differences may be noted dependent upon the pollen supplied for a given cross. These differences are not in immediate relation to the variety of pollen supplied, but depend upon complex factors which will be analyzed in subsequent publications. Furthermore the effect of the crosses may be toward increased color in one cross and decreased color in another, etc. So far as the effect on the fruit is concerned it is absolutely safe and advisable to plant two varieties of different color, shape, etc. together. A red apple will be just as red if pollinated with pollen from a green variety as if pollinated with a red pollen variety. Of course the seeds resulting from such crosses will be different in the two cases, but the flesh or marketable portion will remain unchanged.

This conclusion would be expected from other independent evidence taken from histological studies of the development of the apple. The apple is like an enlarged branch of the mother tree. It does not receive anything of a genetic nature from the resulting union of the pollen and the ovule. It only acts like a sack to protect the seed. It is all maternal in origin and would therefore be expected to assume the maternal characters, size, shape, quality and color, of the mother tree.

If we look at the problem in the light of the preceding data on the self sterility and the cross sterility of the different varieties it is found that the number of fruit set from self fertilizaion is so limited as to make it entirely likely that the large proportion of the apples in commercial orcharding are the result of cross fertilization. Thus in table 2, one of the best commercial varieties, the Baldwin, matured on self fertilization 20 fruit out of 409 trials, a percentage of about 5. On cross fertilization this variety produced good fruit in something over 50 per cent of the crosses which were made. The Ben Davis variety matured no fruit in Maine on self fertilization yet this variety is capable of bearing a crop of a color and size consistant with the best of the variety even though the majority of fruit must have been formed by cross fertilization with a foreign pollen. In view of what the investigations on the causes of self sterility have shown in relation to the growth of the pollen tube it would seem more probable that in the commercial orchard the percentage of fruit set from self fertilization would be considerably below the percentage obtained in experimental work. Thus

given an even start the growth of the pollen tube in the style of the compatible pollen is so rapid as compared with the growth of the pollen tube of the incompatible pollen that in the majority of cases the compatible pollen would beat out the incompatible pollen in the fertilization of the ovule. Such a competitive race is, of course, eliminated in experimental work where the incompatible pollen and that only is allowed to grow in the style. Should it be assumed, however, that the number of fruit matured for the other stations is more representative of the percentages matured for the Maine Ben Davis orchards even this percentage (it is only about 1.5) will not account for the crop of fruit obtained in some of the favorable apple years, when this fruit is all of excellent size and color. These facts all strengthen the conclusions as expressed above and as demonstrated by controlled experiment in Arkansas that the color of the fruit, the size and other characteristics of the variety are as pronounced in the apple resulting from cross fertilization as they are from the apple resulting from self fertilization.

It may therefore be safely concluded that the data on cross fertilization in the apple show that an increased yield results and the size, color and quality of the apples are equal to those from self pollination. To be commercially desirable an orchard should, therefore, be a mixture of the varieties which have compatible pollen.

This conclusion may seem contrary to what is considered good commercial practice which has in the past favored large blocks of a single variety of apple. As shown above by results only recently determined, the apple tree must be crossed fertilized to produce good, regular crops of commercially desirable fruit. By this it is not meant that an orgy of promiscuous regrafting or planting of many varieties in one block is advocated. It means simply that two varieties which are reciprocally compatible should be planted together. The trees for pollination may be reduced to a minimum of only 5 per cent or one tree in 20. In planting every fourth tree in each fourth row is the pollenizer to accomplish this result. Promiscuous grafting is likewise bad commercially since it makes harvesting especially difficult. If it is desired to grow the varieties in equal proportions alternate blocks of not more than 4 or 5 rows may be

planted. In any case not more than 4 or 5 rows should separate the pollenizer trees from those to be pollinated.

For orchards already planted, regrafting a desirable pollenizer in the above mentioned proposition may be practiced. While waiting for these pollenizers to grow to bearing age a practical relief may be had by cutting large branches of other good pollinating varieties and placing them in water pails hung from the tree limbs.

Experiment has shown that little pollen fertilization is brought about by wind. Insects, wild and cultivated are the best agents to transport pollen from one variety to another. It is therefore commercially profitable to keep bees in the orchard for this purpose even though no honey is produced.

Causes of Self Sterility and Cross Sterility.

Sterility within the different species of plants appears to be due to several causal agents. These agents may be external or they may be internal. The external agents include such things as disease affecting the vitality of the tree or its blossoms such as scab, fire-blight, insect infections, spray injury before, during or after flowering. Low temperature and cold continued rains at flowering time may be other factors determining the amount of fruit set and consequently its yield. These factors are more or less under the control of the apple grower and should receive careful attention. They need not be discussed here for the remedial agents are well known.

The internal causes for sterility include degenerate pollen; pollen which is not able to cooperate properly with the style to facilitate the growth of the pollen tube at a sufficient rate of growth to reach the ovule and cause fertilization; and lack of proper development of ovule.

Within the apple the phenomena of self sterility is apparently quite universal. The crosses of the varieties which are self sterile with pollen which is crossed fertile with them show that the ovules are capable of fertilization and are therefore not responsible for the sterility resulting from the self fertilization. Similarly the argument could be made that since the pollen from a self sterile variety is capable of fertilizing other varieties the

pollen as such is not responsible in self sterile varieties of apples for the fruits not setting.

Investigation shows that the problem is one of the interrelation between the pistil and the pollen and the pollen tube. It has been shown that in the self sterile varieties self fertilized the pollen tube grows much more slowly than does the pollen tube of other varieties of pollen when used on the same pistils.* Thus in the self fertilized flower the rate of growth of the pollen tube is so slow that it cannot traverse the length of the style and fertilize the ovule before the ovule withers and dies. With the cross pollinated flowers the pollen tube grows much more rapidly and easily reaches the ovule in time for fertilization to take place. The physical basis of one form of this sterility is consequently due to some factors which inhibit the growth of the pollen tube in the style of the same variety. What this difference is, is a matter now under further investigation.

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APPENDIX TABLE 1.

Apples Resulting from Selfing and Crossing of Varieties.

Selection Number	Parents: Mother Parent	Parents: Pollen	Diameter	No. Seeds
146	Baldwin	x Baldwin	5.6 cm.	2 g — 2 P
230	Baldwin	x Baldwin	5.7 cm.	6 g — 2 P
231	Baldwin	x Baldwin	6.6 cm.	— 6 P
248	Baldwin	x Baldwin	6.8 cm.	3 g —
249	Baldwin	x Baldwin	7.1 cm.	3 g — 1 P
		Average	6.36 cm.	2.8 g — 2.2 P
147	Golden Russett	x Ben Davis	6.6 cm.	10 g
148	Golden Russett	x Ben Davis	6.7 cm.	9 g
149	Golden Russett	x Ben Davis	6.6 cm.	7 g — 1 P
152	Golden Russett	x Ben Davis	5.8 cm.	8 g —
150	Golden Russett	x Ben Davis	5.4 cm.	3 g — 5 P
		Average	6.22 cm.	7.4 g — 1.2 P
16	Hurlbert Sweet	x Ben Davis	7.2 cm.	5 g — 4 P
15	Hurlbert Sweet	x Ben Davis	7.2 cm.	4 g — 4 P
18	Hurlbert Sweet	x Ben Davis	7.1 cm.	4 g — 3 P
		Average	7.17 cm.	4.3 g — 3.7 P
7	Ben Davis	x Canada Red	6.2 cm.	6 g — 1 P
8	Ben Davis	x Canada Red	5.8 cm.	4 g — 2 P
9	Ben Davis	x Canada Red	6.6 cm.	6 g — 1 P
10	Ben Davis	x Canada Red	6.5 cm.	8 g — 1 P
11	Ben Davis	x Canada Red	7.0 cm.	4 g — 4 P
12	Ben Davis	x Canada Red	7.3 cm.	6 g — 1 P
13	Ben Davis	x Canada Red	7.0 cm.	6 g —
14	Ben Davis	x Canada Red	6.8 cm.	4 g — 1 P
		Average	6.65 cm.	5.5 g — 1.4 P
3	Hurlbert Sweet	x Canada Red	6.7 cm.	3 g — 3 P
20	Ben Davis	x Crab	5.7 cm.	5 g
22	Ben Davis	x Crab	6.3 cm.	5 g — 1 P
23	Ben Davis	x Crab	6.2 cm.	4 g
26	Ben Davis	x Crab	6.7 cm.	6 g — 1 P
27	Ben Davis	x Crab	6.4 cm.	7 g — 1 P
29	Ben Davis	x Crab	6.6 cm.	6 g
30	Ben Davis	x Crab	7.3 cm.	4 g
19	Ben Davis	x Crab	6.0 cm.	3 g — 4 P
21	Ben Davis	x Crab	5.4 cm.	1 g — 4 P
24	Ben Davis	x Crab	5.9 cm.	2 g — 3 P
25	Ben Davis	x Crab	5.8 cm.	3 g — 2 P
28	Ben Davis	x Crab	6.7 cm.	7 g — 1 P
		Average	6.25 cm.	4.4 g — 1.4 P
153	Baldwin	x Duchess	7.0 cm.	4 g — 3 P
144	Early Harvest	x Duchess	?	9 g
145	Early Harvest	x Duchess	?	7 g
		Average	?	8 g
163	Baldwin	x Golden Russett	5.5 cm.	6 g
164	Baldwin	x Golden Russett	6.0 cm.	5 g
165	Baldwin	x Golden Russett	6.5 cm.	2 g — 5 P
166	Baldwin	x Golden Russett	5.5 cm.	3 g — 4 P
167	Baldwin	x Golden Russett	6.3 cm.	2 g — 7 P
168	Baldwin	x Golden Russett	6.8 cm.	2 g — 6 P
169	Baldwin	x Golden Russett	5.5 cm.	1 g — 2 P
170	Baldwin	x Golden Russett	6.1 cm.	1 g — 7 P
171	Baldwin	x Golden Russett	6.3 cm.	6 g — 3 P

Apples Resulting from Selfing and Crossing of Varieties.
—Continued.

Selection Number	Parents: Mother Parent	Parents: Pollen	Diameter	No. Seeds
172	Baldwin	x Golden Russett	6.5 cm.	5 g — 1 P
173	Baldwin	x Golden Russett	5.7 cm.	5 g — 2 P
174	Baldwin	x Golden Russett	6.3 cm.	3 g — 3 P
175	Baldwin	x Golden Russett	6.2 cm.	4 g — 4 P
176	Baldwin	x Golden Russett	7.0 cm.	6 g — 3 P
177	Baldwin	x Golden Russett	6.2 cm.	5 g — 1 P
178	Baldwin	x Golden Russett	6.8 cm.	7 g —
179	Baldwin	x Golden Russett	5.8 cm.	3 g — 3 P
180	Baldwin	x Golden Russett	6.4 cm.	4 g — 3 P
181	Baldwin	x Golden Russett	5.4 cm.	3 g — 4 P
182	Baldwin	x Golden Russett	6.0 cm.	6 g — 3 P
183	Baldwin	x Golden Russett	6.2 cm.	4 g — 2 P
185	Baldwin	x Golden Russett	6.7 cm.	6 g —
186	Baldwin	x Golden Russett	7.4 cm.	8 g —
187	Baldwin	x Golden Russett	6.6 cm.	6 g — 3 P
188	Baldwin	x Golden Russett	6.7 cm.	— 4 P
190	Baldwin	x Golden Russett	6.5 cm.	3 g — 3 P
191	Baldwin	x Golden Russett	7.4 cm.	2 g — 1 P
192	Baldwin	x Golden Russett	7.7 cm.	4 g — 4 P
193	Baldwin	x Golden Russett	6.6 cm.	2 g — 1 P
194	Baldwin	x Golden Russett	6.9 cm.	1 g — 6 P
195	Baldwin	x Golden Russett	6.6 cm.	2 g — 4 P
196	Baldwin	x Golden Russett	6.5 cm.	3 g — 3 P
197	Baldwin	x Golden Russett	7.2 cm.	2 g — 5 P
198	Baldwin	x Golden Russett	6.3 cm.	2 g — 5 P
200	Baldwin	x Golden Russett	5.7 cm.	2 g — 2 P
201	Baldwin	x Golden Russett	6.5 cm.	6 g — 1 P
202	Baldwin	x Golden Russett	5.7 cm.	3 g — 5 P
203	Baldwin	x Golden Russett	6.3 cm.	5 g —
204	Baldwin	x Golden Russett	5.4 cm.	3 g — 4 P
205	Baldwin	x Golden Russett	6.2 cm.	1 g — 6 P
207	Baldwin	x Golden Russett	6.5 cm.	2 g — 3 P
208	Baldwin	x Golden Russett	6.2 cm.	2 g — 6 P
209	Baldwin	x Golden Russett	6.9 cm.	4 g — 4 P
210	Baldwin	x Golden Russett	6.5 cm.	2 g — 3 P
184	Baldwin	x Golden Russett	6.0 cm.	9 g —
189	Baldwin	x Golden Russett	6.6 cm.	8 g —
199	Baldwin	x Golden Russett	6.5 cm.	5 g —
206	Baldwin	x Golden Russett	6.3 cm.	7 g —
		Average	6.36 cm.	3.81g — 2.8 P
227	Ben Davis	x Golden Russett	5.0 cm.	5 g — 2 P
228	Ben Davis	x Golden Russett	5.4 cm.	9 g
229	Ben Davis	x Golden Russett	5.6 cm.	4 g
242	Ben Davis	x Golden Russett	6.0 cm.	7 g
243	Ben Davis	x Golden Russett	6.3 cm.	6 g — 2 P
		Average	5.66 cm.	6.2 g — 0.8 P
4	Ben Davis	x Gravenstein	6.6 cm.	1 g — 1 P
5	Ben Davis	x Gravenstein	6.2 cm.	2 g
6	Ben Davis	x Gravenstein	6.8 cm.	2 g
		Average	6.53 cm.	1.7 g — 0.3 P
31	Ben Davis	x McIntosh	6.2 cm.	8 g
32	Ben Davis	x McIntosh	6.2 cm.	6 g — 1 P
33	Ben Davis	x McIntosh	6.0 cm.	7 g — 1 P
34	Ben Davis	x McIntosh	6.8 cm.	5 g
35	Ben Davis	x McIntosh	6.9 cm.	5 g — 1 P
36	Ben Davis	x McIntosh	6.1 cm.	3 g — 2 P
37	Ben Davis	x McIntosh	6.6 cm.	3 g — 4 P
38	Ben Davis	x McIntosh	6.2 cm.	6 g — 4 P

Apples Resulting from Selfing and Crossing of Varieties. —Continued.

Selection Number	Parents: Mother Parent	Parents: Pollen	Diameter	No. Seeds
39	Ben Davis	x McIntosh	6.6 cm.	5 g
40	Ben Davis	x McIntosh	5.9 cm.	7 g — 1 P
41	Ben Davis	x McIntosh	6.4 cm.	7 g
42	Ben Davis	x McIntosh	5.9 cm.	6 g — 2 P
43	Ben Davis	x McIntosh	5.8 cm.	4 g — 5 P
44	Ben Davis	x McIntosh	5.8 cm.	5 g — 4 P
45	Ben Davis	x McIntosh	6.6 cm.	7 g — 1 P
46	Ben Davis	x McIntosh	6.3 cm.	8 g —
47	Ben Davis	x McIntosh	6.5 cm.	7 g — 2 P
48	Ben Davis	x McIntosh	6.4 cm.	7 g — 2 P
49	Ben Davis	x McIntosh	6.9 cm.	7 g
50	Ben Davis	x McIntosh	6.5 cm.	5 g — 3 P
51	Ben Davis	x McIntosh	6.7 cm.	8 g — 1 P
52	Ben Davis	x McIntosh	6.8 cm.	7 g —
53	Ben Davis	x McIntosh	5.8 cm.	5 g — 3 P
54	Ben Davis	x McIntosh	6.5 cm.	8 g — 2 P
55	Ben Davis	x McIntosh	6.0 cm.	7 g —
56	Ben Davis	x McIntosh	6.6 cm.	6 g — 1 P
57	Ben Davis	x McIntosh	6.5 cm.	8 g — 2 P
58	Ben Davis	x McIntosh	6.5 cm.	7 g
59	Ben Davis	x McIntosh	6.1 cm.	4 g — 1 P
60	Ben Davis	x McIntosh	6.2 cm.	2 g — 4 P
61	Ben Davis	x McIntosh	6.5 cm.	7 g — 1 P
62	Ben Davis	x McIntosh	6.3 cm.	8 g — 1 P
63	Ben Davis	x McIntosh	6.7 cm.	9 g —
64	Ben Davis	x McIntosh	6.9 cm.	7 g — 1 P
65	Ben Davis	x McIntosh	6.6 cm.	6 g — 1 P
66	Ben Davis	x McIntosh	6.6 cm.	6 g —
67	Ben Davis	x McIntosh	6.3 cm.	7 g — 1 P
68	Ben Davis	x McIntosh	7.0 cm.	6 g — 1 P
69	Ben Davis	x McIntosh	6.1 cm.	8 g
70	Ben Davis	x McIntosh	5.8 cm.	8 g — 1 P
71	Ben Davis	x McIntosh	5.6 cm.	7 g — 1 P
72	Ben Davis	x McIntosh	4.9 cm.	1 g — 5 P
73	Ben Davis	x McIntosh	6.8 cm.	6 g —
74	Ben Davis	x McIntosh	6.3 cm.	6 g — 1 P
75	Ben Davis	x McIntosh	6.1 cm.	6 g —
76	Ben Davis	x McIntosh	5.8 cm.	8 g —
77	Ben Davis	x McIntosh	5.9 cm.	6 g — 2 P
78	Ben Davis	x McIntosh	6.1 cm.	5 g — 1 P
79	Ben Davis	x McIntosh	7.8 cm.	9 g —
80	Ben Davis	x McIntosh	6.4 cm.	4 g — 2 P
81	Ben Davis	x McIntosh	6.6 cm.	8 g —
82	Ben Davis	x McIntosh	7.0 cm.	7 g —
83	Ben Davis	x McIntosh	6.7 cm.	9 g —
84	Ben Davis	x McIntosh	6.5 cm.	7 g — 1 P
85	Ben Davis	x McIntosh	6.4 cm.	7 g — 1 P
86	Ben Davis	x McIntosh	6.4 cm.	6 g
87	Ben Davis	x McIntosh	6.8 cm.	5 g — 1 P
88	Ben Davis	x McIntosh	6.5 cm.	8 g
89	Ben Davis	x McIntosh	5.8 cm.	3 g — 3 P
90	Ben Davis	x McIntosh	5.3 cm.	8 g
91	Ben Davis	x McIntosh	5.9 cm.	8 g
92	Ben Davis	x McIntosh	6.5 cm.	5 g — 1 P
93	Ben Davis	x McIntosh	6.5 cm.	6 g — 1 P
94	Ben Davis	x McIntosh	6.3 cm.	7 g
95	Ben Davis	x McIntosh	5.6 cm.	7 g
96	Ben Davis	x McIntosh	7.0 cm.	8 g
97	Ben Davis	x McIntosh	6.4 cm.	7 g — 1 P
99	Ben Davis	x McIntosh	5.8 cm.	5 g
100	Ben Davis	x McIntosh	5.6 cm.	6 g
101	Ben Davis	x McIntosh	6.9 cm.	8 g — 1 P
102	Ben Davis	x McIntosh	5.6 cm.	4 g — 1 P
235	Ben Davis	x McIntosh	5.5 cm.	5 g
236	Ben Davis	x McIntosh	5.5 cm.	4 g — 2 P
241	Ben Davis	x McIntosh	4.5 cm.	2 g — 3 P
		Average	6.28 cm.	6.2 g — 1.1 P

Apples Resulting from Selfing and Crossing of Varieties.
—Continued.

Selection Number	Parents: Mother Parent	Parents: Pollen	Diameter	No. Seeds
151	Ben Davis	x Northern Spy	5.4 cm.	5 g —
154	Ben Davis	x Northern Spy	5.9 cm.	6 g
156	Ben Davis	x Northern Spy	4.7 cm.	2 g
157	Ben Davis	x Northern Spy	5.0 cm.	8 g
158	Ben Davis	x Northern Spy	5.2 cm.	9 g
159	Ben Davis	x Northern Spy	5.2 cm.	9 g
244	Ben Davis	x Northern Spy	5.4 cm.	3 g — 1 P
238	Ben Davis	x Northern Spy	5.2 cm.	7 g
237	Ben Davis	x Northern Spy	5.9 cm.	9 g
234	Ben Davis	x Northern Spy	5.5 cm.	5 g — 2 P
233	Ben Davis	x Northern Spy	4.5 cm.	5 g — 3 P
247	Ben Davis	x Northern Spy	3.9 cm.	4 g
250	Ben Davis	x Northern Spy	5.2 cm.	5 g
251	Ben Davis	x Northern Spy	6.1 cm.	5 g
		Average	5.22 cm.	5.9 g — 0.4 P
160	Golden Russett	x Northern Spy	5.2 cm.	7 g
161	Golden Russett	x Northern Spy	5.6 cm.	7 g
162	Golden Russett	x Northern Spy	?	9 g
		Average	5.4 cm.	7.7 g
103	Ben Davis	x Opalescent	6.7 cm.	6 g — 3 P
104	Ben Davis	x Opalescent	6.1 cm.	3 g — 6 P
105	Ben Davis	x Opalescent	7.3 cm.	8 g — 1 P
106	Ben Davis	x Opalescent	6.1 cm.	7 g — 1 P
107	Ben Davis	x Opalescent	6.0 cm.	7 g
108	Ben Davis	x Opalescent	6.7 cm.	7 g
109	Ben Davis	x Opalescent	6.2 cm.	6 g — 1 P
110	Ben Davis	x Opalescent	5.9 cm.	6 g — 1 P
111	Ben Davis	x Opalescent	7.1 cm.	8 g
112	Ben Davis	x Opalescent	5.8 cm.	5 g — 2 P
113	Ben Davis	x Opalescent	5.6 cm.	12 g
114	Ben Davis	x Opalescent	5.1 cm.	9 g — 1 P
115	Ben Davis	x Opalescent	6.6 cm.	8 g
116	Ben Davis	x Opalescent	6.4 cm.	7 g
117	Ben Davis	x Opalescent	6.5 cm.	6 g
118	Ben Davis	x Opalescent	6.8 cm.	7 g
119	Ben Davis	x Opalescent	7.0 cm.	7 g
120	Ben Davis	x Opalescent	6.8 cm.	7 g
121	Ben Davis	x Opalescent	6.2 cm.	5 g — 3 P
122	Ben Davis	x Opalescent	5.7 cm.	5 g
123	Ben Davis	x Opalescent	6.3 cm.	7 g — 1 P
124	Ben Davis	x Opalescent	6.4 cm.	6 g
125	Ben Davis	x Opalescent	6.3 cm.	8 g
126	Ben Davis	x Opalescent	6.4 cm.	8 g
127	Ben Davis	x Opalescent	6.6 cm.	9 g — 1 P
128	Ben Davis	x Opalescent	6.2 cm.	4 g — 3 P
129	Ben Davis	x Opalescent	6.1 cm.	9 g
130	Ben Davis	x Opalescent	6.2 cm.	7 g — 1 P
131	Ben Davis	x Opalescent	6.1 cm.	8 g
132	Ben Davis	x Opalescent	7.4 cm.	7 g — 1 P
133	Ben Davis	x Opalescent	6.0 cm.	7 g
134	Ben Davis	x Opalescent	6.5 cm.	8 g — 2 P
135	Ben Davis	x Opalescent	6.3 cm.	7 g
142	Ben Davis	x Opalescent	6.6 cm.	8 g
143	Ben Davis	x Opalescent	7.4 cm.	6 g
		Average	6.48 cm.	7 g — .8 P
1	McIntosh Red	x Opalescent	6.4 cm.	7 g
2	McIntosh Red	x Opalescent	5.9 cm.	6 g — 1 P
		Average	6.15 cm.	6.5 g — 0.5 P

Apples Resulting from Selfing and Crossing of Varieties.
—Concluded.

Selection Number	Parents: Mother Parent	Parents: Pollen	Diameter	No. Seeds
136	Ben Davis	x St. Lawrence	6.7 cm.	7 g
137	Ben Davis	x St. Lawrence	6.5 cm.	4 g
138	Ben Davis	x St. Lawrence	7.1 cm.	10 g
139	Ben Davis	x St. Lawrence	6.6 cm.	5 g
140	Ben Davis	x St. Lawrence	7.0 cm.	7 g
141	Ben Davis	x St. Lawrence	6.6 cm.	4 g — 1 P
		Average	6.75 cm.	6.1 g — 0.2 P
211	Ben Davis	x Wealthy	5.1 cm.	7 g
212	Ben Davis	x Wealthy	4.5 cm.	5 g — 1 P
213	Ben Davis	x Wealthy	4.6 cm.	3 g — 5 P
214	Ben Davis	x Wealthy	4.9 cm.	7 g
215	Ben Davis	x Wealthy	5.1 cm.	7 g
216	Ben Davis	x Wealthy	5.7 cm.	6 g
217	Ben Davis	x Wealthy	4.9 cm.	— 6 P
218	Ben Davis	x Wealthy	4.4 cm.	1 g — 5 P
219	Ben Davis	x Wealthy	5.4 cm.	g — 9 P
220	Ben Davis	x Wealthy	4.3 cm.	4 g — 2 P
221	Ben Davis	x Wealthy	5.0 cm.	— 8 P
222	Ben Davis	x Wealthy	5.0 cm.	7 g
223	Ben Davis	x Wealthy	5.0 cm.	5 g
224	Ben Davis	x Wealthy	4.1 cm.	5 g
225	Ben Davis	x Wealthy	5.1 cm.	7 g
226	Ben Davis	x Wealthy	6.0 cm.	5 g
		Average	4.94 cm.	4.3 g — 2.3 P
232	Wealthy	x Wealthy	?	4 g

BULLETIN 288

SOME OBSERVATIONS UPON THE EFFECT OF BORAX IN FERTILIZERS.

W. J. Morse.

SUMMARY

Unexpected and material losses in the form of partial or almost total crop failure occurred in 1919 on a large number of Maine potato fields where the customary relatively large applications of commercial fertilizer were made. Injury to the parts of the plants below ground was apparent early in the season. In severe cases many plants failed to reach the surface of the ground and those that grew had a characteristic appearance differing from types of injury or disease previously observed.

Field studies, covering a wide variety of conditions, showed that these losses were, for the most part, confined to the fields where fertilizers manufactured by certain individual companies were applied. Moreover the trouble appeared to be associated with the potash used in the manufacture of these fertilizers, for it did not occur where the no-potash fertilizers put out by the same concerns were used.

The Station chemist found boron present in appreciable amounts in these fertilizers wherever samples could be obtained of those used on the fields where the type of injury in question appeared. No definite cases of similar injury were observed where it could be shown that borax-free fertilizers carrying approximately similar amounts of nitrogen, phosphoric acid and potash were applied.

Limited experiments have been made with pot cultures in the greenhouse in which fertilizers containing borax were applied to potatoes, beans, oats, wheat and buckwheat.

With potatoes samples of 6 different lots of fertilizer sold in Maine in 1919 were used. At the rate of application the amount of anhydrous borax used varied from nothing to 38.6 pounds per acre, the most extensive trials being at the rate of 17.6 pounds per acre.

The results of the greenhouse experiments to a large extent confirm the field observations. Potato plants in pots containing no commercial fertilizer and those in pots to which a borax-free fertilizer was added were free from injury. No plants which received fertilizer containing borax escaped injury in some form or other. In general the amount of injury varied with the amount of fertilizer used, but the results were not unifrom in this respect.

Except where the largest amount of borax was applied, the type of injury in the greenhouse differed in some important respects from that observed in the field. Killing of the tips and margins of the leaves was characteristic of the greenhouse potato plants. At the rate of 17.6 pounds of anhydrous borax per acre the most severe leaf injury was obtained where the fertilizer was mixed with the upper 6 inches of soil in the pot or with the 3 inches of soil below the seed-piece and the plants heavily watered. The larger applications of boron caused greater root injury, more stunting of the plants and less tip and marginal injury to the leaves.

An application of fertilizer in the drill equivalent to 4.4 pounds anhydrous borax per acre caused severe injury to beans, while broadcasting the same fertilizer, applying the equivalent of 8.8 pounds anhydrous borax per acre caused no apparent injury to oats, wheat and buckwheat.

INTRODUCTION.

The soils of New England are particularly free from substances which are deleterious to plant growth. Hence the apparent presence of some poisonous salt in the fertilizer used by many potato growers in Maine in the season of 1919 presented an entirely new problem to the farmers and the fertilizer trade and to the students of plant diseases as well.

Certain difficulties had been experienced in the use of chemical commercial fertilizers coincident with the partial and later the total disappearance on the market of European potash as the result of the war. Partly because experiments conducted by this Station and partly because the experience of certain practical growers had shown that on the Caribou loam, the most extensive and best type of potato soil in the State, the potash content of the fertilizers could be reduced materially without greatly lessening the potato crop, but more on account of the fact that

potash was high in price and was for the most part unobtainable, a large amount of no-potash fertilizers were used for the first time in 1916. Most frequently these contained 5 per cent of ammonia and 10 per cent of available phosphoric acid and were known as 5-10-0 goods.

A "new potato disease" made its appearance in July of that season. The foliage of the affected plants, instead of being a normal, healthy dark green, showed first a peculiar bronzing and yellowing. As the disease progressed the plants had, on casual inspection, much the appearance of potatoes just previous to ripening. In the final stages the leaflets hung limp and the entire plant wilted. Usually discolored areas appeared on various parts of the stems. A very characteristic feature of the trouble was the formation of a dry, discolored, spongy area which involved the whole stem just at the surface of the ground. Following this discoloration of the basal portions of the stem the tissues would dry out, the stem would become hollow at that point and the plant would fall over. Cross sections of the stem sometimes showed a discoloration of the water or food conducting vessels.

When the trouble first appeared in 1916 there was some reason to suspect that it was of a parasitic nature. The various lesions scattered over the stems were of a light brown or reddish brown color and later usually showed a lighter colored center. A number of different fungi were found to be associated with the lesions, but most frequently the lighter colored portion would be studded over with the fruiting bodies of a fungus of the genus Phoma. Repeated attempts to reproduce the disease in healthy plants by inoculation with cultures of this and other fungi isolated from spots on potato stems obtained from different parts of the State resulted in failure. This seemed to disprove the theory of a parasitic cause of the disease.

It was soon discovered that this so-called "new disease" occurred only where the 5-10-0 fertilizers were used and there, in destructive amounts, it was largely confined to the poorer types of soil. Even small amounts of potash in commercial fertilizers or the application of relatively small amounts of stable manure in addition to the 5-10-0 fertilizer would correct the difficulty. Later experience fully confirmed the conclusions

reached in 1916 that the fundamental cause of this trouble was lack of potash in the fertilizer.*

These experiences led Maine potato growers to demand that the manufacturers supply them with fertilizers containing potash. The manufacturers met this demand as far as possible, using various American sources of this material, but it was not till 1919 that relatively large amounts of such fertilizers were sold which contained potash in amounts at all comparable to that used before the war. The so-called Searles Lake deposits in California being the largest and most promising source of American potash were naturally used in many cases. These deposits are not pure potash salts but contain mixtures of other materials, including compounds of boron. Certain samples of this potash, used in the manufacture of fertilizer that came to the attention of the Station in 1919 contained the equivalent of from 5 to 10 per cent of sodium biborate or borax.

No attempt will be made to discuss in this publication the general problem of the effect of boron or its compound borax upon plant growth or to review previous literature upon this subject. It may be said, however, that it is only within a very short time that it has even been suspected that the small amounts of borax that have been found in the fertilizers under consideration would prove so toxic to farm crops as now appears to be the case.

Neither is an attempt made to discourage the use of American potash, provided it can be produced cheaply enough so that American farmers can afford to use it and provided it can be sufficiently freed from deleterious impurities so that it can be used with safety. The experiences of the past few years simply serve to emphasize the importance and even the necessity for all concerned to unite in supporting, in every way possible,

*For some reason, possibly due to more general use of stable manure, this trouble did not attract much attention in southern New England till later. In 1918 it was sufficiently common in southern Connecticut and on Long Island and surrounding territory to cause much comment and alarm. Here again there was a strong tendency to look upon it as a parasitic disease with Phoma as the causal fungus. On the other hand Dr. Geo. P. Clinton, after a thorough canvass of the situation seems to have reached, in part, similar conclusions as to the fundamental cause, as were obtained in Maine. (See Potato Magazine Vol. 1, No. 12, June, 1919. Prematuring and Wilting of Potatoes, G. P. Clinton.)

any movement which has for its object making American agricultural and manufacturing interests partially or wholly independent of foreign sources of potash. In this connection it may be said that the company principally interested in marketing potash from the Searles Lake deposits states that with improved methods of refining they are now putting out a potash in which the amount of borax is reduced to less than one per cent.

SOME PRACTICES FOLLOWED BY MAINE POTATO GROWERS.

Methods of growing the potato crop vary considerably in different parts of the country. It may, therefore, assist the general reader if a brief statement is made relative to certain of the practices followed in Aroostook county where most of the observations were made upon the effect of borax in fertilizers. While there are numerous variations, potatoes usually follow clover in a 3-year rotation, in which oats constitute the third crop. While some stock is kept, the great majority of potatoes are grown upon chemical fertilizers supplemented by humus obtained from clover sod alone or from this and "second-crop" clover plowed under the fall before.

In the last 20 or more years the amount of commercial fertilizer used has gradually and quite materially increased until now an application of 2000 pounds per acre is not an uncommon practice and some growers use more than this. With few exceptions this fertilizer is all applied in the drill at planting time. Some planters distribute it above the seed-piece and some below. Those planters in most general use do not deposit the fertilizers in direct contact with the seed-piece, but close to it and not mixed very much with the soil.

Formerly, when potash was relatively low in price, it was not uncommon to apply fertilizers containing as high as 10 per cent of this ingredient. A 4-6-10 was one of the mixtures popular with Maine potato growers in 1914 and for some years previous. The samples collected by the Bureau of Inspections of the State Department of Agriculture and analyzed by the Station chemists show that the amount of potash in the special potato fertilizers had dropped to 4 per cent or lower in 1915. In 1916 only a few samples of 4-per cent goods were found. For the most part the fertilizers found that year contained one

or two per cent of potash and many none at all. Conditions improved somewhat in 1917, there being more evidence of 3 and 4-per cent goods. A still greater proportion of the 1918 samples were of the 4-per cent potash grade, while in 1919 some 6-per cent goods were found. With the reduction in the amount of potash used in potato fertilizers sold in Maine during the last 5 years there has been a tendency to increase the amount of phosphoric acid, not because experience had indicated any need for this, but apparently because it was the cheapest and most plentiful fertilizing material that the manufacturers could obtain.

It is interesting to note that, in spite of these wide variations in the composition of the fertilizers used, no general complaints have been made by the potato growers, previous to 1919, of ill effects from their use, except where 5-10-0 or similar mixtures were used, although in 1918 there was some undercurrent of feeling that the results obtained from goods carrying American potash were not quite up to expectations. While it is an open question whether such excessive applications of potash as are made when 2,000 pounds of fertilizer per acre are used, containing 10 per cent of this material is necessary or wise, the results obtained from the practice previous to 1914 were such as to convince many practical potato growers that it was good business. The only bearing that the question has on the matter under consideration is that it serves to emphasize the fact that even excessive applications of the type of potash used prior to 1914 resulted in no dissatisfaction on the part of the users.

FIELD OBSERVATIONS ON INJURED POTATO FIELDS IN 1919.

Early in July 1919 rumors began to reach the Station that some fields of potatoes in Aroostook County were not showing normal germination and growth. Definite complaints began to be received about the middle of July by both the State Department of Agriculture and the Experiment Station. The Director of the Station, and the Chiefs of the Bureaus of Inspections and Seed Improvement of the State Department at once decided to make a joint, personal investigation of the situation. As a member of this party the writer spent 10 days in the field studying conditions at that time. During the remainder

of the growing season considerable attention was given to similar field studies in various sections of the State.*

It soon developed that the trouble was confined largely to the fertilizers manufactured by certain individual companies and, as far as the writer observed, to the brands put out by these companies which contained 4 or 6 per cent of potash. Wherever samples could be obtained of the goods used, the analyses made by the Station chemist showed the presence of borax in appreciable amounts. It later developed that borax might be present in a fertilizer from other sources, from mixtures of nitrate of potash and soda for instance, but in the field observations under consideration the trouble seemed always associated with the potash used. For example, some fields were seen where a part was planted with a fertilizer containing potash, and another part planted with a no-potash fertilizer put out by the same concern. The plants where the last named material was used appeared strong and vigorous when examined the latter part of July, while those where the potash goods were used showed various degrees of what will be described as borax injury.

NATURE AND AMOUNT OF INJURY OCCURRING ON POTATO FIELDS AND ITS RELATION TO THE FERTILIZER USED.

Although the type of injury may differ, as will be pointed out later, the presence of even small amounts of borax in a fertilizer when such fertilizer is applied at the rate of a ton per acre has a very marked effect on the potato plant, both in the field and in the greenhouse. In the field the casual observer first notes, in severe cases, a stunted appearance of the plants, with an abnormal number of "skips" or failures to germinate. Such a field is shown in the foreground of Fig. 14. Note the vigorous growth and even stand of the plants in the background. This portion of the field was planted three weeks after the first.

*The writer was especially fortunate in being able to inspect a large number of these fields in company with Dr. George H. Pethybridge, Economic Botanist to the Department of Agriculture and Technical Instruction for Ireland, Dr. A. D. Cotton, Mycologist to the Ministry of Agriculture and Fisheries, London, and Mr. E. J. Wortley, Director of Agriculture, Bermuda, all of these gentlemen being potato-disease specialists of international reputation.

A 4-8-6 fertilizer was applied in the same manner in each case, but different lots obtained from different manufacturers were used.* Equally striking differences were observed from the use of these two fertilizers on the same field, using the same seed planted the same day. All injury disappeared at the exact point where one fertilizer ran out and the other was placed in the planter.

On severely injured fields, like that mentioned above, a close inspection revealed the fact that there were few normal plants. At the time when the plants on uninjured, near-by or adjoining fields were for the most part strong and vigorous and nearly covered the ground, those where the injury occurred presented a very striking contrast. An occasional plant might be found which approached normal appearance, but for the most part those that came were weak and sickly looking, many being only two or three inches high. An intertesting fact was noted that many of these stunted plants blossomed at the same time as healthy plants of the same age.

The foliage of the injured plants, where borax was present in the fertilizer, had a characteristic appearance. There was considerable yellowing of the leaves, more particularly of the margins. This was most prominent on the more dwarfed and more severely injured plants. The yellowing was of a bright golden color, and not the pale, sickly yellowing usually present in plants that are normally or prematurely ripening. In the milder cases the abnormal color was restricted to the extreme edges of the leaves. In fact, as field observations progressed, the appearance of this very narrow band of yellow at the mar-

*Unfortunately samples of these two lots of fertilizer could not be obtained for analysis. The only evidence that the differences shown on the adjoining portions of this field was due to the presence of boron in one of the fertilizers used is that wherever it was possible to obtain samples of the same brand of fertilizer where it had been used on fields that showed similar injury, these samples contained borax in more than appreciable amounts. On the other hand no samples of the other brand were found which contained any borax. Only one complaint was received where any of the goods manufactured by this concern were used. Here no sample could be obtained. The writer examined the field in question and, while it was seen too late in the season to form an accurate opinion, was not convinced that the owner's contention that he had a case of borax injury was correct.

gins of the leaves, particularly the lower ones, came to be looked upon as an important diagnostic character in cases of suspected borax injury, where the effects were not sufficient to produce serious stunting and failures to germinate. In severe cases the leaves themselves were frequently narrowed and in certain instances the smaller leaves at the top were noted as folded upward on the mid-rib.

FIG. 14. Two different brands of 4-8-6 fertilizer were used on this field. The portion shown in the background was planted 3 weeks later than that where the weak, scattered plants occur. See foot-note on p. 96.

On many borax injured fields, for the most part planted during the last two weeks in May, a marked change began to take place about the first of August. The plants which survived started to grow and, as a result, many of the more marked symptoms of the trouble as already described either disappeared or became masked by the growth of the plant. This apparent recovery is explained on p. 100. The only borax injured potato field that the writer was able to visit at regular intervals throughout the season, indicated that this improvement in the condition of the plants came too late to materially aid in producing a crop. This seemed to be the general opinion of owners of fields which showed similar conditions.

The parts below ground showed other striking evidences of injury. The nature of this injury varied somewhat with the type of planter used, that is, whether the planter deposited the fertilizer above or below the seed piece. It also varied with the amount of borax-containing potash which was applied. For example, the injury where a 4-8-6 fertilizer was used was more severe, as a rule, than where the same amount of 4-8-4 goods from the same manufacturer was applied.

As might be expected some of the worst cases of injury observed were those where the fertilizer was deposited above the seed piece and the stem of the plant had to grow up through it. On one such field in particular there was a large amount of browning of the stems in the region of the fertilizer. Many cases were found where the stem was entirely cut off and in some instances it had sent out new branches from below, which in turn might or might not be cut off. Injury to the stems below ground also frequently occurred where the fertilizer was deposited below the seed piece but this was more often close to the base or point of attachment of the stem.

The lesions somewhat resembled those caused by Rhizoctonia, but were invariably much lighter brown in color and were more likely to entirely encircle the stem. Rhizoctonia may or may not be present as a complicating factor, but there is plenty of evidence in the line of field observations which indicate that neither it nor any other parasitic fungus is a material factor in the production of stem lesions which are attributed to the presence of borax in the fertilizer used. For example, the owner of the field shown in Figure 15 used a fertilizer containing borax up to the point where the stake is placed in the row. At this point he changed to another brand of fertilizer of the same formula but which contained no borax, and immediately continued planting. The plants on the left showed all the typical symptoms of severe borax injury described above and numbers of them selected at random showed the stem browning and injury in practically every case. On the other hand the plants of the portion of the field at the right of the stake, where the other fertilizer was used, were normal in appearance, nearly covered the ground at the time the record was made, and showed no evidence of injury to the parts below ground.

FIG. 15. A fertilizer containing borax was applied to the left-hand portion of this field. The stake in the row at the center marks the point where the owner changed to a fertilizer of the same formula, but containing no borax.

FIG. 16. A 3-6-6 fertilizer, with a smaller amount of 5-10-0 applied later, was used on the two and a fraction rows beginning with the point marked with the hat and ending at the point where the stake is placed. The potatoes on either side were fertilized with 5-10-0 alone. See p. 102.

FIG. 17. The plants on the left received a small amount of fertilizer containing borax. Those on the right received no fertilizer. See p. 103.

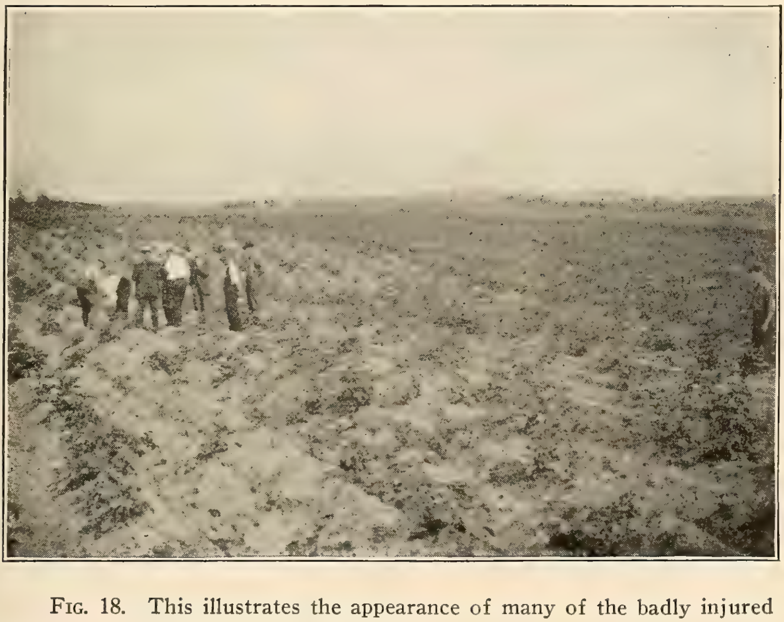

FIG. 18. This illustrates the appearance of many of the badly injured fields during the latter part of July.

FIG. 19. Bad cases of borax injury in the field. This represents the entire growth made by the plants in three months. Note that the root system is almost entirely destroyed. Compare with Fig. 21.

Browning and killing of the roots was a very prominent sign of the trouble, being more pronounced in the case of the badly dwarfed plants. This condition is well illustrated by Figure 19 from a photograph made on August 13. It will be noted that in spite of the fact that the seed pieces had been planted nearly 3 months the plants had made practically no growth above the surface of the ground. The roots had been killed off at the base and there were no roots present at the nodes of the stem, where it was covered with soil, as would normally be the case. Of the roots at the base of the stem, whether the fertilizer was applied above or below the seed peice, frequently nothing remained but a tuft of dried, brown stubs.

Seed-pieces in direct contact with the fertilizer often showed a burning and erosion of the cut surfaces. In general, however, the presence of borax seemed to have a preservative

effect on the seed-piece, since there was a marked absence of decay in the latter where fertilizers were used which contained it in considerable quantities.

Plants which survived till the middle of the summer usually began to put forth roots from the stem close to the surface of the ground or in the region most remote from the point of application of the fertilizer.* These plants, if they had not been too severely injured, then began to grow fairly rapidly as the result of the partial establishment of a new root system in the hilled-up soil, out of contact with the fertilizer. As has already been stated the yellowing and other evidences of injury disappeared more or less completely with the new growth. This belated or secondary growth of the injured plants tended also to obscure the number of missing hills and thus improved the appearance of the affected fields generally. Such of these fields as it was possible to observe from time to time during the season proved very deceptive to those who were not familiar with their history. The yields of tubers were far from what might be expected from the appearance of the partially recovered plants. One field in particular, which the writer had under observation during the latter part of the growing season, showed marked improvement during August and September, but the owner obtained only about one-third of a normal yield. The fertilizer used carried 0.88 per cent anhydrous borax and at the rate used was equivalent to an application of 17.6 pounds of anhydrous borax per acre.

The above description of the injury to potatoes in the field and attributed to the presence of borax in the fertilizer used, applies more particularly to the severe cases. All gradations between this and fairly normal plants might be found on the same field. A few mild cases of injury were seen where it was rather difficult to decide whether or not the trouble was due to the presence of borax in the fertilizer. Some of these were

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*For the benefit of those who are not familiar with the cultural practices followed with potatoes in Maine it may be said that it is customary to cover the plants with a horse hoe as soon as they begin to break ground. This is repeated when the plants begin to appear a second time. Hence a considerabe ridge or hill is already formed from the surface soil, well above the seed-piece and fertilizer, before the plants finally come up.

seen so late in the season that most of the prominent symptoms had disappeared. None of these were classed as borax injury unless fairly conclusive evidence such as the characteristic stem and root burning could be obtained. In this connection it may be said that in every one of such mild or doubtful cases where field observations gave presumtive evidence of borax injury and samples of the fertilizer could be obtained the samples were found by the chemists to carry borax in appreciable amounts.

No attempt has been made by the present writer to secure data as to the yields on any considerable number of fields where borax injury occurred, but numerous cases have been reported where the yields were not over half or one-third of a normal crop and some of the more severely injured fields would hardly produce a sufficient crop to pay the cost of harvesting.

The early part of the growing season of 1919 in Aroostook county was quite dry. In a few instances much less injury was observed on the lower and less thoroughly drained portions of the fields. In one case the owner planted part of a field a few days before a heavy shower and finished the remainder of it after the rain. Much less injury occurred on that part of the field planted after the rain. Since borax is readily soluble, these observations suggested that it was carried away by the soil water and that in seasons of ordinary rainfall in June much less injury from borax might be expected. Other observations indicated that more thorough mixing of the fertilizer with the soil than is commonly practiced would prevent or materially reduce the amount of injury. In the greenhouse experiments described later an attempt was made to test these theories and it will be seen that they were not wholly confirmed.

In studying conditions in the field it soon developed that there was sufficient evidence of a general nature to convince the average person that the trouble under consideration was associated with the fertilizer applied, moreover, that it was in some way connected with the potash used in the fertilizer in most instances. On the other hand many individual cases of themselves, when considered alone, fell far short of actual proof of this, or of proof approximating that which can be obtained through experimental evidence. However, a few fields of potatoes were found which provided conditions approaching

those which might be selected under actual experiment. Two of these will be described by way of illustration.

Mr. A. on one side of a field of several acres applied a 3-6-6 fertilizer at the rate of 1700 pounds per acre, all in the drill at planting time. Next to this, a section of the field was planted with 1300 pounds of the 3-6-6 goods per acre in the drill, with 500 pounds of a 5-10-0 fertilizer applied later on top of the row. Next came 4 rows with 1700 pounds per acre of 5-10-0 applied in the drill at planting time. Then following were two and a fraction rows with 1300 pounds per acre of 3-6-6 in the drill at planting time and with 500 pounds of 5-10-0 on top of the row, the same as the second section of the field described. The remainder of the field was planted with 5-10-0 goods at the rate of 1700 pounds per acre in the drill at planting time.

When examined first on July 21 the plants where the 5-10-0 fertilizer was used alone were, on the average, strong and vigorous. Where the 3-6-6 fertilizer was used alone or in combination with the 5-10-0 goods there appeared, in addition to numerous "skips" or failures to produce plants, the characteristic stunting of the plants, with yellowing of the leaves, more especially at the margins, and varying amounts of injury to the parts below ground. The injury was more pronounced where the 1700 pounds per acre of the 3-6-6 fertilizer was applied in the drill at planting time than where only 1300 pounds of this fertilizer was used at that time and 500 pounds of 5-10-0 was applied later.

Figure 16 is from a photograph of the two and a fraction rows which received 1300 pounds per acre of the 3-6-6 in the drill and 500 pounds of the 5-10-0 later. On either side are rows of plants which had 5-10-0 alone at the rate of 1700 pounds per acre in the drill. The barrel stave in one row indicates where one fertilizer gave out and the other began.

Mr. B. had a field of 44 acres of potatoes, on which he applied a 4-8-4 fertilizer in the drill. He began to plant using this at the rate of 2400 pounds per acre. Later he cut the amount down to 2000 pounds per acre. Then seeing that he had an insufficient amount of fertilizer to finish the piece, and being unable to secure an additional supply, he reduced the amount from time to time till he reached the minimum that the planter

would apply. Finally he ran out of fertilizer and finished the piece without any.

It was impossible to locate with any degree of accuracy where all of these changes in the amounts of the fertilizer application were made on this field, but one had no difficulty in locating the exact point where he began to plant with no fertilizer at all. The plants where no fertilizer was used were more vigorous and uniform than those on any other portion of the field. The contrast between the appearance of the plants where no fertilizer whatever was used and those next to them that received only a small amount of fertilizer is shown in Fig. 17.

Fig. 18 is a fairly representative illustration of the conditions observed on this field and numerous others during the latter part of July, 1919.

Where the larger amounts of fertilizer were used there were many missing hills. The plants averaged small and weak with yellowing of the margins of the lower leaves. The smaller leaves at the tops of the more stunted plants were folded together. Not much stem injury was noted at the time of observation, but frequently the stems were found to be those which had branched up from below where the original stems had been killed below ground and had entirely disappeared.

The injury appeared in different degrees on all parts of the field to which the fertilizer was applied, but with each decrease in the amount of application it was evident that there was a corresponding decrease in the amount of injury produced. In a few instances the differences between adjoining sections of the field were sufficiently marked to indicate the probable point where the changes were made on the planter to reduce the amount of fertilizer application.

GREENHOUSE EXPERIMENTS WITH FERTILIZERS CONTAINING BORAX.

The close relation between the presence of borax in the fertilizers used and the injury which occurred on many potato fields, as shown by the observations made during the summer of 1919, led to the planning of certain greenhouse experiments with fertilizers, with and without borax, using potatoes, beans,

oats, wheat and buckwheat. The results reported here are those obtained from what from the first have been regarded as preliminary studies, but it is believed that they are of sufficient significance to be of value as a matter of record at this time.

These preliminary experiments possess certain limitations, some of which will be mentioned. While, as will be seen, the results with potatoes and beans were quite striking and uniform, a larger number of pots for each individual treatment would have been better. The relatively small number of pots used was partly due to the limitations imposed by lack of greenhouse space, but more particularly in the case of potatoes it was due to the fact that at the time the work was begun, October 3, it was difficult to secure a sufficient amount of satisfactory seed potatoes in condition for immediate germination. While the results show that fertilizers containing borax produced varying amounts of injury to potatoes and that such injury did not occur on plants in pots containing borax-free fertilizer or in pots containing no fertilizer, they do not show conclusively that borax is the sole and only factor involved. They furnish very strong presumptive evidence that this is the case. There are also certain objections that might be raised to the method used in applying water to the pots.

Plans were made whereby it was intended to repeat and amplify these experiments to meet the objections enumerated, as far as the limitations of greenhouse space would permit. It was then found that the Directors of the other Agricultural Experiment Stations in New England, New York and New Jersey were interested in joining in conducting a cooperative greenhouse experiment on a relatively large scale in which the effects of the presence of different amounts of borax in fertilizers when used on potatoes, corn and beans would be determined. Arrangements were perfected whereby this work was begun about February 1, the final plans being prepared by the Director of the Maine Station and the writer. To Mr. J. R. Neller of the New Jersey Station, an expert in pot culture, was assigned the responsibility of carrying out the details of these cooperative experiments, which are now in progress in the Vermont Station greenhouses.

As soon as the plans mentioned above were perfected, work along similar lines was discontinued at Orono. The following

concerns only the results previously obtained in the preliminary experiments at this Station, or between October 1, 1919, and about January 15, 1920.

WORK WITH POTATOES.

Soil. The soil used for potatoes was a medium heavy loam which had been under cultivation for many years, being used each year for garden purposes. In recent times it has had an application of barnyard manure on alternate years and commercial fertilizer applied yearly. It was taken directly from the garden and placed in pots in the greenhouse.

Kinds of fertilizers used and amounts applied. Six different brands of fertilizers, made by five different concerns and sold in Maine in 1919, were used. In every instance the applications of all fertilizers to pots containing potatoes were made at planting time and as nearly as possible at the rate of 2,000 pounds per acre. The usual fertilizer analysis of each lot had been made by the Station chemists, including a quantitative determination for borax. These results and certain other data, including the number of pounds of anhydrous borax used when the several fertilizers are applied at the rate of 2,000 pounds per acre, are shown in tabular form.

Table Showing Composition of Fertilizers Used.

Station No.	Composition	Per cent of anhydrous borax	Pounds of anhydrous borax per acre	Number of pots used
5549	4-8-6*	0.88	17.6	20
5389	4-8-6	0.35	7.0	4
5518	3-6-6	0.93	18.6	4
5536	3-6-6	1.44	28.8	4
5513	4-8-6	1.93	38.6	4
5409	4-8-6	0.00	00.0	4
Checks, no fertilizer	——	——	——	4

*The figures in this column represent approximately the per cents of ammonia, available phosphoric acid and potash respectively.

Variation in methods of application of fertilizer. As will be seen by the number of pots given in the right-hand column of the table, the most extensive trials were made with

fertilizer No. 5549 which, when applied at the rate of 2,000 pounds per acre, was equivalent to an application of 17.6 pounds of anhydrous borax per acre. With this fertilizer the 20 pots were divided into 5 different lots of 4 pots each, according to the method of application. In the first lot the fertilizer was thoroughly mixed with the upper 6 inches of soil in each pot. In the second it was distributed in a strip about 3 inches wide across the pot (in a manner similar to the way it is deposited in the row in the field by the planter) just below the seed-piece, but not in direct contact with it. In the third the fertilizer was distributed in a manner similar to the second, but just above the seed-piece. In the fourth lot it was thoroughly mixed with the 3 inches of soil just below the seed-piece, while in the fifth it was thoroughly mixed with the 3 inches of soil above the seed-piece.

With each of the remaining 5 fertilizers, namely, Nos. 5389, 5518, 5536, 5513 and 5409, only 4 pots were used, representing two pots each of the second and third methods of application described for No. 5549. Four other pots were planted with potatoes without adding any fertilizer. These and those in which fertilizer No. 5409 was used, which contained no borax, were introduced as checks.

Seed tubers used. There were available a small amount of tubers which had been produced in pots in the greenhouse, harvested in the early summer and stored in a cool basement. These were firm and vigorous and some were just beginning to sprout at the time of planting. A half of a tuber was placed in each pot, care being taken to distribute the halves so that no two would have the same fertilizer treatment.

Depth of planting. In all cases the distance was 3 inches from the top of the seed-piece to the top of the soil after planting. Wherever the fertilizer was distributed in drills above or below the seed-piece without mixing with the soil, a thin layer of soil was placed between it and the seed-piece.

Watering. All of the pots which were 10-inch and of the ordinary unglazed type, were placed on benches with saucers underneath. One-half of all of the pots, representing the different methods of application of the various fertilizers, were kept heavily watered, while the other half had a scanty water supply or were kept as dry as possible and still have them moist enough for growth. As a rule this required about 300 and 150

cc. of water respectively per pot daily. All of the water was applied in the saucers, thus making the water current always upward through the soil in the pot.

Temperature. The temperature control was set at about 70 degrees F. during the day and from 50 degrees to 55 degrees F. during the night. During the night of December 15 on account of the failure of the University heating plant to furnish sufficient steam the temperature fell to the danger limit and some of the plants nearer the walls of the house were frozen. This seriously interfered with certain features of the work and made it impossible to make some desired photographic records, but it did not materially affect the final results and conclusions.

Records. While changes in the appearance of individual plants were noted as soon as they appeared, detailed records of the growth and appearance of each plant were made weekly. At the close of the experiment all plants were removed from the pots and the root systems separated from the soil as carefully as possible and examined for injury.

RESULTS OBTAINED FROM GREENHOUSE EXPERIMENTS WITH POTATOES.

Except for some mosaic the unfertilized check plants remained perfectly healthy till they were removed from the pots 3 months after planting. The plants in the pots containing the borax-free fertilizer No. 5409 were entirely free from any evidence of fertilizer injury or disease. This entire lot was included in the few plants which were badly injured by frost. However, all of the other plants which developed borax injury had shown it, in marked degree, some time previously. Of the 4 pots fertilized with No. 5409 one was about 9 inches high and the other 3 about 15 inches high when killed by frost on December 15. Unfortunately no photographs had been taken to show their appearance at that date. All that can be said is that at this time the health and vigor of these 4 plants showed a marked contrast to the other 40 in the experiment, including the unfertilized checks.

No plants which received fertilizer containing borax escaped injury in some form or other. In general the amount of injury varied with the amount of borax present in the fertilizer

Fig. 20. These two plants were photographed about two weeks after appearing above ground. The fertilizer used in pot 32 carried a relatively high percentage of borax, while that applied to pot 44 contained no borax. See p. 109.

Fig. 21. This represents the total growth made in the greenhouse in three months by one of the plants fertilized with No. 5513, equivalent to 38.6 pounds of anhydrous borax per acre. Compare with Fig. 19.

used, but the results were not entirely uniform in this respect. As might be expected the most severe injury occurred with fertilizer 5513 where the amount of anhydrous borax applied was equivalent to 38.6 pounds per acre. The 4 plants in this series were much stunted and yellowed, although those having the fertilizer applied above the seed-piece finally made a partial recovery and attained a height of 7 and 12 inches respectively in 3 months time. The early condition of the last mentioned or larger plant is shown in Fig. 20, pot 32. At that time it was weak and yellowed. The plant in pot 44 was grown on fertilizer No. 5409 which contained no borax. The two plants germinated within two days of each other and were about two weeks above ground when the photograph was made. The two plants where fertilizer 5513 was placed below the seed-piece made very little growth. At the end of 3 months one consisted of simply a rosette of small leaves just at the surface of the soil. See Fig. 21. The other was only 3 inches high.

The amount of injury obtained with fertilizer No. 5389 where the application of anhydrous borax was equivalent to 7 pounds per acre was somewhat surprising. Not only was there some stunting and yellowing of the plants where the fertilizer was applied below the seed-piece, but a considerable amount of the type of injury next to be described was present on all of them.

THE MOST COMMON TYPE OF INJURY TO POTATOES IN THE GREENHOUSE.

While some of the plants in the greenhouse, more particularly in the case of heavy applications of borax, showed the yellowing and a stunted, shrubby appearance similar to that characteristic of plants in the field where borax was present in the fertilizer used, this was not general. Yellowing was more or less in evidence in a number of cases when the plants were young but this usually disappeared as they became older. Quite a different type of injury occurred, without exception but in varying degree, upon all plants which were grown in pots containing a fertilizer which carried borax.

This type of injury was characterized by death and drying out of the tips and margins of the leaflets. The injury first

appeared on the basal leaves and afterwards on the upper ones, and almost without exception was noted on the tips of the leaflets first and then on the margins. While the whole margin might be affected, the trouble was more severe and appeared first on the half of the leaflet nearest the tip. In like manner the terminal and first two lateral leaflets were attacked first and were more severely affected. Fig. 22 shows a plant all of the leaves of which are affected in this way. The injury was first observed between two and three weeks after the plant came up and the photograph was made six weeks after that. At that time the two lower leaves had fallen and two more were about ready to fall.

FIG. 22. Type of injury most common in the greenhouse. The tips and margins of practically all of the leaves are affected. See also Fig. 26, p. 117.

The age of the leaf seemed to be a determining factor. A lower leaf might be badly affected while the leaves from a young

shoot formed in its axil would appear entirely healthy at the same time. However these leaves from the younger shoots nearer the base later showed the same marginal injury.

The dead tissues suggested more of an olive tinge than a browning. A comparison with standard color charts failed to match any shade or tint of brown except possibly in the case of the first appearance of the injury on the tip of a leaflet. The color was difficult to match and about the best description that can be given is that it resembled most closely what might be expected where a potato leaf had been killed rapidly and quickly dried with little yellowing.

The appearance of the affected leaves seemed to indicate simply a progressive death and drying out of the tissues. While there was a fairly sharp line of demarkation between the diseased and healthy portions of the leaves, the latter near this line usually showed more or less fading out of the normal green color to a lighter green or even a yellowish tinge. In advanced stages the leaf-blades themselves would become yellow, soon followed by the dropping of the leaf. Some of the more severely injured plants lost all of their leaves before they were dug up early in January.

In some instances there was a suggestion of what has been called "tip-burn" of the potato. However, there is no reason for confusing this tip and marginal injury on greenhouse plants, resulting from borax applied to the soil with the fertilizer, with the usual forms of the tip-burn in the field. It occurred under relatively humid conditions, at a time of the year when sunlight was at its lowest intensity, and in greater degree on the plants supplied with an abundance of moisture. The plants were entirely free from insects of all kinds.

Several facts, taken together, strongly suggest that this tip and marginal injury is the direct result of the accumulation of compounds of boron in the tissues affected. Droplets of liquid were constantly observed upon the tips and margins of the leaflets of potato plants grown in the greenhouse particularly at the times when no other explanation could be given for their presence, except that they exuded from the leaves themselves. Moreover faint traces of a whitish deposit were repeatedly seen on these leaves in the same locations after the droplets had evaporated. This condition was found to be common and was

in no way restricted to plants grown in pots containing borax or to plants included in the experiments under consideration.

The size and rapidity of growth of many of the plants which showed this type of injury in marked degree, particularly those which were heavily watered, indicated considerable root growth and this was confirmed by later examination. Likewise plants which suffered severe root injury and stunting as the result of heavy applications of borax showed relatively smaller amounts of the tip and marginal injury. Therefore it seemed reasonable to suppose that compounds of boron were being taken up by the roots, were being carried along with dilute solutions of food materials and deposited in the leaves. Since there is constant evaporation of water from the leaves and a fairly constant current of water from the roots upward through the stems and continuing through the leaves to the margins of the latter, it would seem that any materials or salts brought along in solution in this transpiration current, which were not used by the leaves in the manufacture of food materials for tissue building or for storage, would tend to concentrate most at or near the margins and that this concentration would be greater in the older leaves. A sufficient concentration of any poisonous material would result in the death of the tissues at that point.

To test the above assumption with reference to boron in the plants in question some of the dead margins of the injured leaves were removed with scissors. At the same time an approximately equal amount of the margins of healthy leaves was obtained from plants which were grown upon fertilizer No. 5409 which contained no boron. These were tested qualitatively by the Station chemist on December 3, or two months after the tubers were planted. The sample from the injured leaves gave a positive test for boron while that from the healthy leaves gave a negative test.

RELATION OF THE TIP AND MARGINAL INJURY OF THE LEAVES TO THE METHOD OF APPLICATION OF THE FERTILIZER AND WATERING.

Based upon the larger series of pots with fertilizer 5549 where the applications of anhydrous borax were equivalent to 17.6 pounds per acre, fertilizer applied below the seed-piece,

whether mixed or unmixed with the soil, caused greater tip and marginal injury than where it was applied above the seed-piece. Mixing fertilizer with the soil resulted in greater leaf injury, unless it was mixed with the soil above the seed-piece. Abundant watering increased the amount of leaf injury. Stated in another way, the most severe leaf injury was obtained where the fertilizer was mixed with the upper 6 inches of soil or with the 3 inches of soil below the seed-piece and the plants heavily watered.

It will be remembered that with the remaining 5 lots, the fertilizer was applied only in the drill, both above and below the seed-piece. Half of the pots in each lot were abundantly watered and the other half scantily watered. As has been stated very healthy, vigorous plants were obtained with No. 5409 which contained no borax. The other 4 lots which represented varying applications of borax gave results in general agreement, as far as they went, with those given above for No. 5549. The most severe injury of both types resulted from the application of the fertilizer below the seed-piece, and abundant watering—as a rule—produced more tip and marginal injury.

On account of the relatively small rainfall in Aroostook county in June, 1919, the water supply for the plants, previous to the appearance of the injury in the field, where most of the more serious cases were seen, was largely from below upward. A desire to duplicate field conditions as nearly as possible was what led the writer, in planning the greenhouse experiments, to decide to make all applications of water to the pots from below. The results obtained indicate quite clearly that the method of watering adopted, materially influenced the relative amounts of leaf injury which resulted from the variation in the methods of fertilizer application. Continued watering from above has still greater objections as it would have a tendency to carry the borax away from the plants. Alternate watering from above and below, such as was decided upon in the case of the cooperative experiments now in progress, undoubtedly is the nearest approach to field conditions that can be obtained in the greenhouse. It is granted that, in the confined conditions imposed by the pot, there is less opportunity for the plant to escape from the poisonous action of the borax, but in spite of this fact and the objection to the method of watering mentioned above it is

believed that these greenhouse experiments may serve as a fairly accurate index of the relative amounts of the various forms of injury which may be expected from the application of like amounts of borax to potatoes in the field.

ROOT INJURY IN POTS.

The potato plants were all removed from the pots early in January and an examination was made of the root systems. While care was exercised to remove them in as nearly a natural condition as possible it was extremely difficult to separate them from the soil without breaking off many of the finer rootlets. Hence the illustrations show the relative and not the absolute conditions.

The plants which were grown upon fertilizer No. 5409, free from borax, had long fibrous roots running to the bottom and penetrating to all parts of the pots. Fig. 23 shows the root system of one of these plants.

FIG. 23. Root system where borax-free fertilizer, No. 5409, was used in pots in the greenhouse.

As might be expected the most severe root injury occurred where the fertilizer was applied in drills, unmixed with the soil. This was more pronounced in the presence of the larger amounts of borax and showed a distinct correlation with stunting and yellowing of the plants, or with the prevailing type of injury which was observed in the field during the previous summer. Fig. 21 shows a plant having a very severe type of injury where practically the whole root system had been destroyed. It also illustrates the entire growth made by this plant during a period of 3 months. This was obtained with fertilizer 5513, or where an application of 38.6 pounds of anhydrous borax was made per acre.

Where the fertilizer was applied above the seed-piece the injury was least near the base of the plant. Where it was applied below the seed-piece it was least near the surface of the soil. Rather marked cases of these forms of root injury are shown in Figs. 24 and 25. It will be noted that while a part

FIG. 24. Root injury to plant in greenhouse where fertilizer containing borax was placed in the pot above the seed-piece unmixed with the soil.

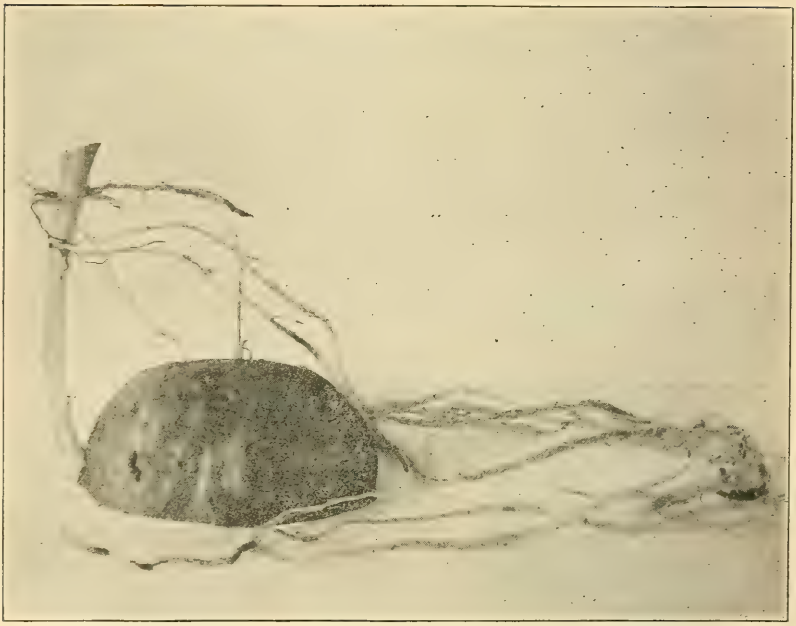

FIG. 25. Root injury in greenhouse where the same fertilizer as was used on the plant, the root system of which is shown in Fig. 24, was placed in the pot below the seed-piece unmixed with the soil.

of the roots which have grown out near the surface of the soil from the stem shown in Fig. 25 have been killed, 3 long, fibrous ones remain. In such cases the roots ran along near the surface till the wall of the pot was reached. Then they passed downward through that portion of the soil in the pot that was more remote from the fertilizer. This condition, of course, only obtained where the fertilizer was applied in the drill below the seed-piece. It was exactly in accord with what was observed repeatedly under like conditions in the field.

It may be of interest to briefly sketch the history of the plant shown in Fig. 25. The seed-piece was planted October 3, using fertilizer 5513. The plant broke ground on November 18, but it was less than one inch high on December 1. (Plants grown on 5409, carrying the same amounts of ammonia, phosphoric acid and potash, were from 8 to 14 inches high at this time). By December 15 it was about 1½ inches high, and was 3 inches high on January 1. At that time it had the curled,

stunted and yellowed appearance similar to that of badly injured plants in the field. Undoubtedly, if allowed to grow, it would have shown the partial recovery that was observed with those plants in the field which produced roots that started near the surface of the ground and penetrated the soil remote from the fertilizer.

Root injury was less severe where fertilizer was mixed with the soil above and below the seed-piece than where it was placed in drills above and below. Little or no root injury could be found where the fertilizer was mixed with the upper six inches of soil in the pots. However, as has already been stated, it was where the fertilizer was mixed with the soil that most of the tip and marginal injury of the leaves was obtained. The root system of one of the plants where the fertilizer was mixed with the upper six inches of soil is shown in Fig. 26. The ap-

FIG. 26. Root system of plant shown in Fig. 22. The fertilizer, No. 5549, was mixed with the upper six inches of soil in the pot. The root injury was slight but the leaf injury was marked.

pearance of the plant itself on January 1 is shown in Fig. 22. The record states that at that time the margins of all leaves were badly affected, the two lowest leaves had fallen and the next two were about ready to fall.

It should be remembered that tests with fertilizer mixed with the soil were confined to No. 5549, or with applications of 17.6 pounds of anhydrous borax per acre. Undoubtedly greater root injury from mixing fertilizer with the soil would have been obtained if the samples carrying higher percentages of boron had been used in this way.

WORK WITH OTHER CROPS.

The work of testing the effects produced upon crops other than potatoes by fertilizers containing borax was only incidental, was planned simply as preliminary tests, and was conducted upon too small a scale to be of much value. The results obtained with beans in comparison with those obtained with other crops were of such a striking character that it is desirable to record them in detail. No. 5549 was the only fertilizer used, and regular greenhouse potting soil was employed.

Beans. Three different varieties of beans were used. The seed of two of them was produced in 1918 and the other in 1919. Three eight-inch pots were used for each variety. Fertilizer 5549 was applied to two of these and nothing added to the third pot which served as a check in each instance. The potting soil contained an abundance of natural fertilizer.

The fertilizer was applied at the rate of 500 pounds per acre in the drill, making an application of anhydrous borax equivalent to only 4.4 pounds per acre. This fertilizer was distributed in a strip 3 inches wide across the soil in a nearly filled pot, and covered with a thin layer of soil. In each pot 6 seeds were evenly spaced in two lines directly over the strip of fertilizer, and then covered with an inch of soil.

All of the beans in the check pots germinated and produced normal, vigorous plants, although those from the variety grown in 1919 came more slowly. The behavior of the beans in the pots containing fertilizer contrasted very strikingly with that of those in the check pots. This was shown by a much delayed

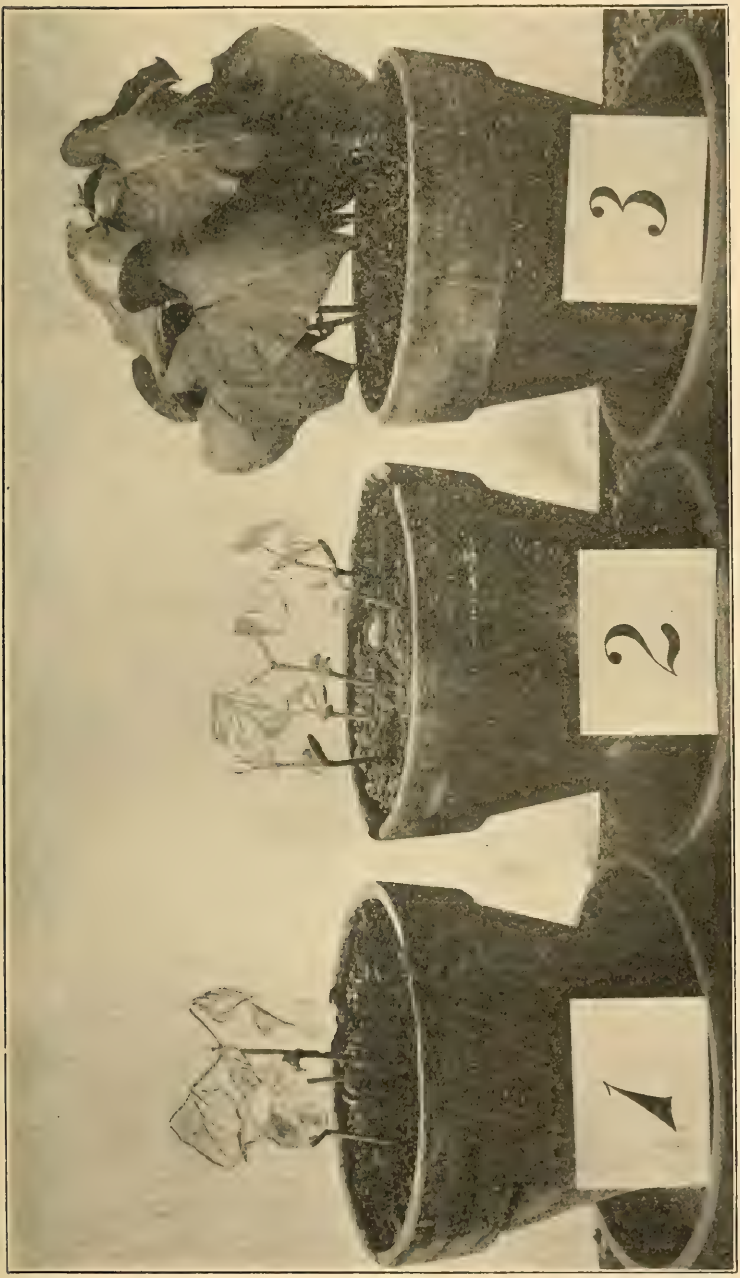

Fig. 27. Beans growing in greenhouse potting soil. To pots 1 and 2 fertilizer No. 5549 was applied at the rate of 500 pounds per acre, equivalent to 4.4 pounds anhydrous borax. No commercial fertilizer was added to pot 3.

or partial failure to germinate and a pronounced lack of green in the leaves of all plants that did grow. In the case of the variety where the seed was grown in 1919, only one plant in each pot containing fertilizer appeared above ground and these plants died almost immediately. In the case of the two varieties from the 1918 seed one finally gave 100 per cent germination in the presence of the fertilizer but the plants grew very slowly, the leaves were stiff and of a pale, waxy color, entirely lacking in chlorophyll. Their appearance as compared with the check, pot 3, is well shown in Fig. 27. This is from a photograph taken about 6 weeks after planting. Eventually all but one plant in each of pots 1 and 2 of this series died. These two plants slowly, but not wholly, developed a normal green color and remained weak and stunted, although they were kept under observation up to the time when the plants in the check pot were practically mature. The series in which the third variety of beans was used showed only 50 per cent germination in the presence of the fertilizer and the history of the injured plants was similar to that given above.

Oats, wheat and buckwheat. Series of pots similar to those described for beans were used for planting oats, wheat, India wheat, old-fashioned buckwheat and Japanese buckwheat. Here the applications of fertilizer 5549 were made at the rate of 1000 pounds per acre, broadcasted, or mixed with the upper inch of soil in the pots. This would make the applications of anhydrous borax 8.8 pounds per acre. No consistent differences could be noted either in germination of the seeds or in the health of the plants growing in the pots which did or did not contain the borax.

BULLETIN 289

THE CORRELATION BETWEEN MILK YIELD OF ONE LACTATION AND THAT OF SUCCEEDING LACTATIONS.*

By John W. Gowen.

SUMMARY

This bulletin presents a study of the accuracy with which the milk production of one lactation indicates the milk production of a subsequent lactation for a pure bred herd of Jerseys under uniform farm conditions. The correlations describing the relation of one lactation with another lactation range from +0.7306 to +0.2144. The numerical value of such correlation coefficients signifies that with a fair degree of accuracy the milk production of one lactation measures the probable milk production of a subsequent lactation.

The arithmetical equations necessary to determine this probable production are given in table 3.

The relation of the milk production of one lactation with the milk production over five lactations is determined. These correlation coefficients range from +0.8613±.0186 to 0.7416 ±.0323. Such high values indicate that with slight inaccuracy the milk production of one lactation predicts the milk production for the first five lactations.

Data are presented to show that the milk production of one lactation is a better measure of a cow's milk production of another lactation than the egg production of one month is of the egg production for the year.

Table 5 furnishes a ready means of determining from the milk yield of the first lactation (8 months of lactation) what

*This paper is an abstract of a longer paper on "Studies in Milk Secretion VI. On the Variations and Correlations of Butter-Fat Percentage with Age in Jersey Cattle" by the same author published in Genetics, March 1920. All literature citations should be made to this complete paper.

the total milk yield of the first five lactations (8 months lactation periods) will be for a Jersey herd of similar milk production to the herd here studied.

In a previous bulletin the variation of milk yield with age has been determined. In the present paper the phase of the problem dealing with one lactation in its relation to another will be considered.

The functioning of the mammary glands may be considered dependent upon three main factors, taken in order of their position in time, heredity, development through feeding, etc., (environmental circumstances of these organs up to their commencing to secrete) and lastly environmental factors in their widest sense acting during the months when the gland is active. It is reasonably clear that on our ability to distinguish the relative influence of these three basic variables depends many of the common *a priori* dairy practices as well as furnishing a solid foundation for the analysis of the causal mechanism of milk production itself. The analysis is a complex one and needs to be attacked by many channels. The present investigation was undertaken in the hope that by an analysis of the intra individual variation of milk secretion from lactation to lactation some light would be given on the relative merits of these three variables. The homogeneous nature of the material is such, however, that the investigation necessarily deals chiefly with the first of these variables.

Little work on milk secretion has been done that approaches the problem from this viewpoint. Of the available data those on the English herds analyzed by Gavin are undoubtedly the best. This investigation on a mixed herd of British Holsteins and grade Short-Horns furnishes data of the value for the records of the first lactation in comparison with the yields of subsequent lactation. In all of this work the measure of the lactation used is what he designates as the "revised maximum," this term being defined as the maximum day yield of the lactation which is three times reached or exceeded. These results are considered largely for their strictly practical bearing. They are of little use to the American farmer in that he is accustomed to deal with records over a certain limit of time and not maximum productions. The constants derived by Gavin will be of a good

deal of interest for comparison data with that presented here as together they show the range of variation to be expected under the different conditions of England and the United States, a mixed herd and a pure bred herd, and a difference in the measure of the lactating capacity from lactation to lactation.

Any adequate analysis of this problem should include a study of the means and standard deviations of milk production for the different age groups into which the lactations are divided. The necessity for such analysis lies in the following fact. If it can be shown that the milk production of the earlier years in a cow's life has been used to select only high producing cows to remain in the herd at later years it follows that the correlations will be for this selected herd and not for the breed as a whole.

The analysis of the means and standard deviations for this data show that no such selection took place. From this it follows that the rise and fall of mean milk production with advancing age shown in the preceding bulletin is due strictly to the physiological changes brought about in the mammary functions of the cow by age. The general equation to this physiological change expresses the law by which it is governed in the same way that Minot, Pearson and others have expressed the similar law for the manner in which the metabolic functions producing growth changes with increasing age.

It further is established that the results to follow are free from any influence of such selection.

THE CORRELATION OF EIGHT MONTHS MILK PRODUCTION AT A GIVEN AGE WITH THE EIGHT MONTHS MILK PRODUCTION AT ANY OTHER GIVEN AGE.

For a firm foundation of our practical agriculture, particularly dairying, knowledge of the inter-relationships of the milk yield at one age in comparison with the milk yield of another age can scarcely be too exact. The existing practice is, as already pointed out, largely empirical in its nature often leading to questionable results. The reflection of the questionable nature of these practices is seen in the not uncommon practice of dairymen neglecting the records of the first lactation as a measure of the cow's possibilities for future milk production.

The correlations between the milk production of various lactations with one another has material importance as well as theoretical interest for these problems. If the correlation is high it is evident from the practical side that the culling of the herd through the use of dependable criteria will result in increase in the milk yield per cow within the herd and in the increase of profits to its owners. From the biological side, a high correlation means that the animals composing the herd innately differentiated (presumably due to their inherited complex) in their mammary capacities.

The determination of the correlations for these data are of especial interest for as previously shown in the earlier part of this paper, the data are of exceptional value in that; they are on a pure bred Jersey herd kept intact for many years; the lactation records for several lactations are recorded on a number of the animals; and the herd has been subject to no detectable culling based on the production of a given lactation. From these data there have been extracted lactation records to the number of 3178 pairs having a full eight months lactation free from any disease or sickness or other trouble known to influence the records. These records have been formed into twenty-eight correlation tables the most of which are of considerable size.

Table 1 gives the correlations and their probable errors for all ages into which the lactation records were divided. The vertical columns give the correlations of the age heading the column with the ages indicated at the left margin of the table. As will be noted the correlations necessary to give the complete set of correlation for any given age are repeated e. g. the correlation of 2 years with 3 years is $+0.5764 \pm .0332$ and appears in the 2 year column. The correlation of 3 years with 2 years will, of course, be the same ($0.5764 \pm .0332$) and is repeated in the three year column. In this manner a complete picture of the relationship of the lactations of the 2 year group with the other lactations of the other groups is given in the column.

The order of magnitude of these correlations is from $+0.7306$ for the correlation of 8 months milk productions during the ages 5 to 6 and 6 to 7 and $+0.2144$ for the correlation of the productions during the ages 4 to 5 and 10 and older. Such correlations indicate that the milk production of one lactation may be predicted with relatively little inaccuracy from the milk production of another lactation.

TABLE 1.

Coefficients of Correlation of Milk Production of a Given Age With the Milk Production of Another Given Age.

Age	2–3	3–4	4–5	5–6
2 to 3	--------------	+0.5764±.0332	+0.5426±.0361	+0.5373±.0406
3 to 4	+0.5764±.0332	--------------	+0.6206±.0335	+0.5479±.0395
4 to 5	+0.5426±.0361	+0.6206±.0335	--------------	+0.5541±.0391
5 to 6	+0.5373±.0406	+0.5479±.0395	+0.5541±.0391	--------------
6 to 7	+0.5500±.0426	+0.5305±.0452	+0.5624±.0421	+0.7306±.0284
7 to 8	+0.5815±.0468	+0.5394±.0483	+0.6328±.0380	+0.5667±.0403
8 to 10	+0.4938±.0488	+0.5376±.0465	+0.4154±.0503	+0.5405±.0397
10 and older	+0.5603±.0732	+0.6336±.0925	+0.2144±.0919	+0.5371±.0697

Age	6–7	7–8	8–10	10 and older
2 to 3	+0.5500±.0426	+0.5815±.0468	+0.4938±.0488	+0.5603±.0732
3 to 4	+0.5305±.0452	+0.5394±.0483	+0.5376±.0465	+0.6336±.0925
4 to 5	+0.5624±.0421	+0.6328±.0380	+0.4154±.0503	+0.2144±.0919
5 to 6	+0.7306±.0284	+0.5667±.0403	+0.5405±.0397	+0.5371±.0697
6 to 7	--------------	+0.6515±.0349	+0.4800±.0427	+0.4578±.0666
7 to 8	+0.6515±.0349	--------------	+0.5750±.0367	+0.3036±.0712
8 to 10	+0.4800±.0427	+0.5750±.0367	--------------	+0.5113±.0448
10 and older	+0.4578±.0666	+0.3036±.0712	+0.5113±.0448	--------------

The graph for the correlations, coefficients of the milk production of one lactation with the milk production of subsequent lactations of the same cows shows little deviation from a straight line. The values of these correlations range from +0.4938 ±.0488 to +0.5815±.0468. The values for the three year correlations with the other years range is somewhat higher +0.5305 ±.0452 to +0.6336±.0925. These correlations would be quite accurately described by a linear function. The values of the correlation of four year old's production with those of other years range from +0.2144±.0919 to +0.6328±.0380. On the whole these values are slightly lower than are those for other years. The values for the five year olds range from +0.5371 ±.0697 to +0.7306±.0284. These values are the highest in their range of any of the ages. The correlations for the six year productions with those of other ages range from 0.4578 ±.0666 to +0.7306±.0284. The correlations for the seven year productions range from 0.3036±.0712 to +0.6515±.0349. The correlations for the 8 and 9 year period range from +0.4154 ±.0503 to +0.5750±.0367 and the correlations for the produc-

tions at 10 years and older with those of the younger years range from $+0.2144 \pm .0919$ to $+0.6336 \pm .0925$. From this brief resume of the tabled results it is seen that all of the results have the plus sign and have a rather large value for data of this kind. The values of the coefficients are in general higher for the younger ages than they are for the older ages. This is a fortunate circumstance from a practical standpoint for the breeder is more desirous of selecting the animal to remain in the herd from their two year records than he is to select his animals at ten years old. The values of the correlations are fortunately such that a gain in accuracy results by predicting from the two year olds as over predictions at later ages.

From the practical side of culling the poor milkers out of the herd these results are highly satisfactory. The data are equally interesting when considered in their biological aspects. The correlation shows that the cows composing the herd are innately differentiated in their milk producing abilities. The plane of production once established the cow tends to maintain this relative plane from lactation to lactation. The value of the correlation indicates clearly that the mechanism behind this function works quite accurately.

From this point of view it is of a good deal of interest to compare the only other statistics available for cattle with those derived here. Gavin using his measure of the lactation, the "revised maximum," found the correlation between the milk productions of the various lactations "revised maximum." Table 2 is a copy of Gavin's table showing these correlations.

TABLE 2.

Lactation	r with max. R. M.	Probable Error
First	+.394	±0.031
Second	+.452	±0.030
Third	+.506	±0.028
Fourth	+.605	±0.024
Fifth	+.762	±0.016

This table shows in general a lower value for the correlations measuring the consistency of milking performance from lactation to lactation than is shown on our data. This may in part be due to the fact that Gavin's material was somewhat

heterogeneous including data from British Holstein and Short-Horns. In all events, the correlations confirm our general conclusions that milk production of one lactation is quite closely correlated with that of the other lactations. This reasoning transferred to the individuals of the race of dairy cattle, appears to prove beyond any shade of doubt that the individuals of the race are innately differentiated as regards the capacity for milk production.

Of the quantitative data on other species of practical interest perhaps the most complete is that of Harris and Blakeslee on the White Leghorn. In this work they determine the correlations between the monthly egg production and the other eleven months production of the same bird. The correlation for these monthly ovulations with the other eleven months ovulation take values ranging from $+0.240 \pm .033$ to $+0.573 \pm .023$. The range is there quite similar to those obtained in this study of milk secretion although lower in value. The knowledge of these sets of constants gives criteria for the fairly accurate prediction of the records that may be expected as a subsequent date in the life of these two extremely important economic species.

From these correlation coefficients in table 2 it is possible to form the straight line prediction of the milk yield of any age from the yield of any other age. As emphasized repeatedly in the various sections of this paper dealing with the separate subjects, the predictions may be criticized on the following grounds; that the mean milk yield rises with age in a line described by a logarithmic function; that the standard deviation of this milk yield rises in line described by a cubic parabola; and that the values of the correlation coefficients differ from the values of the correlation ratios by 2.42 times the probable error of $\eta^2 - r^2$. Such criticisms are recognized and admitted at once. It is believed that even admitting these there are a number of important points which may be elucidated by these equations.

The general equation for these regressions is given by

$$Y = (\text{Mean}_Y - \frac{\sigma Y}{\sigma y} \text{Mean } y) + rYy \frac{\sigma Y}{\sigma y} y$$

TABLE 3.

Regression Equations of the Milk Yield for Any Age from That of Any Lactation Record at Another Age.

AGE AT WHICH EXPECTED MILK YIELD IS DESIRED.

Age at which milk yield was made	2 years to 3 years Regression Equation	3 years to 4 years Regression Equation	4 years to 5 years Regression Equation	5 years to 6 years Regression Equation
2 years to 3 years y_2	------------------	$Y=1515.5+.7922y_2$	$Y=1447.4+.8591y_2$	$Y=1795.7+.8968y_2$
3 years to 4 years y_3	$Y=2130.0+.4194y_3$	------------------	$Y=2013.7+.6500y_3$	$Y=2082.5+.6882y_3$
4 years to 5 years y_4	$Y=2391.2+.3427y_4$	$Y=1656.2+.5935y_4$	------------------	$Y=2007.2+.6325y_4$
5 years to 6 years y_5	$Y=2394.4+.3219y_5$	$Y=2408.3+.4362y_5$	$Y=2513.3+.4855y_5$	------------------
6 years to 7 years y_6	$Y=2456.2+.3018y_6$	$Y=2346.6+.4330y_6$	$Y=3092.2+.3652y_6$	$Y=1624.4+.6708y_6$
7 years to 8 years y_7	$Y=1995.3+.3955y_7$	$Y=2252.6+.4790y_7$	$Y=2345.0+.5149y_7$	$Y=2507.8+.5086y_7$
8 years to 10 years y_8	$Y=2570.8+.2927y_8$	$Y=2437.6+.4433y_8$	$Y=3367.9+.3298y_8$	$Y=2715.2+.4959y_8$
10 years and above y_{10}	$Y=2633.1+.3105y_{10}$	$Y=868.8+.8766y_{10}$	$Y=3952.6+.2190y_{10}$	$Y=2905.2+.5265y_{10}$

Age at which milk yield was made	6 years to 7 years Regression Equation	7 years to 8 years Regression Equation	8 years to 10 years Regression Equation	10 years and above Regression Equation
2 years to 3 years y_2	$Y=1551.7+1.0023y_2$	$Y=1910.8+.8549y_2$	$Y=1710.8+.8329y_2$	$Y=717.0+1.0109y_2$
3 years to 4 years y_3	$Y=2578.2+.6500y_3$	$Y=2502.2+.6075y_3$	$Y=2036.3+.6519y_3$	$Y=2539.6+.4580y_3$
4 years to 5 years y_4	$Y=1158.8+.8662y_4$	$Y=1435.1+.7778y_4$	$Y=2500.7+.5233y_4$	$Y=3711.3+.2100y_4$
5 years to 6 years y_5	$Y=1332.7+.7958y_5$	$Y=2165.0+.6314y_5$	$Y=2087.7+.5890y_5$	$Y=1871.7+.5480y_5$
6 years to 7 years y_6	------------------	$Y=1779.2+.6585y_6$	$Y=2493.0+.5019y_6$	$Y=2681.7+.4147y_6$
7 years to 8 years y_7	$Y=1960.8+.6445y_7$	------------------	$Y=1573.3+.6720y_7$	$Y=3205.1+.3129y_7$
8 years to 10 years y_8	$Y=2989.5+.4591y_8$	$Y=2720.5+.4920y_8$	------------------	$Y=2271.5+.5075y_8$
10 years and above y_{10}	$Y=2899.8+.5053y_{10}$	$Y=3772.8+.2946y_{10}$	$Y=2660.1+.5150y_{10}$	------------------

As the milk production is given in pounds the second term of each of these equations gives the gain in expected milk yield for the given age, if one pound increase in actual production is made during the test. The calculation of an expected yield is, therefore a simple matter of direct substitution.

Thus for the dairyman with a herd of cows producing an amount of milk similar to this herd of Jerseys, suppose one of his cows produces 5000 pounds as a two year old, what would the six year old production be? In the 6 year to 7 year column on line with the 2 years to 3 years is given the equation necessary to solve the problem, $Y=1551.7+1.0023_{y_2}$. The arithmetical computation for each step is $1.0023 \times 5000=5011.5+1551.7$ 6563.2 the pounds of milk expected of the cow at six years. The repetition of this process for any milk production or age gives the desired probable milk yield.

CORRELATION OF ONE LACTATION RECORD WITH THE MILK YIELD FOR THE FIRST FIVE LACTATIONS.

From a practical view point perhaps nothing is more important than a knowledge of the degree of accuracy with which the record of one lactation expresses what the milk yield over a number of lactations will be.

For this purpose a series of data including records of five lactations was chosen. Each of the cows whose records were selected began milking in the second year. The five lactations were consecutive and approximately a year apart depending on how long the previous lactations were continued. The lactation records for the five successive lactations were correlated with the total milk production for the five lactations. The correlation coefficients and other constants for these are given in table 4.

TABLE 4.

Age when lactation commenced	Mean Milk Production	Standard Deviation for the Milk Production	Coefficient of Variation for the Milk Production
2 years to 3 years	4159.1 ± 57.8	803.2 ± 40.8	19.31 ± 1.00
3 years to 4 years	4840.9 ± 86.1	1197.9 ± 60.9	24.74 ± 1.35
4 years to 5 years	5380.7 ± 78.8	1096.2 ± 55.7	20.37 ± 1.06
5 years to 6 years	5568.2 ± 87.1	1211.2 ± 61.6	21.75 ± 1.17
6 years to 7 years	5681.8 ± 91.4	1270.7 ± 64.6	22.36 ± 1.17
Total of five lactations	25613.6 ± 335.9	4672.0 ± 237.5	18.24 ± .94

Age when lactation commenced	Correlation of Individual lactation records and five lactation total Production	Correlation Ratio of Individual lactation records and five lactation total Production	Regression Equations. 8 months lactation and five lactations total Production
2 years to 3 years	+0.7416 ± .0323	+0.7517 ± .0312	$Y_T = 7671.9 + 4.3139 y_2$
3 years to 4 years	.8418 ± .0209	.8856 ± .0155	$Y_T = 9719.5 + 3.2833 y_3$
4 years to 5 years	.8613 ± .0186	.8796 ± .0162	$Y_T = 5861.4 + 3.6710 y_4$
5 years to 6 years	.8250 ± .0230	.8561 ± .0192	$Y_T = 7893.5 + 3.1824 y_5$
6 years to 7 years	.8205 ± .0234	.8466 ± .0203	$Y_T = 8471.9 + 3.0170 y_6$
Total of five lactations			

The high correlation between the record of one lactation and the total production (first five lactation periods) is manifest. The correlations are so high as to lead to the conclusion that the record of one lactation in a cow's life serves to determine the records for the total production in the cow's life.

The comparison of the accuracy with which this control mechanism works with that of similar secretions on other species has a good deal of direct bearing on the subject. The only data available are for the egg of the domestic fowl.

Correlations obtained by Harris and Blakeslee for the successive monthly egg productions of White Leghorn pullets with their first annual production range from $+0.372 \pm .030$ to $0.695 \pm .018$ with an average of 0.556. The correlations of the successive yearly productions and the total of the first five lactations shown in table 4 range from $+0.7416 \pm .0323$ to $0.8613 \pm .0186$. The difference between these correlations is striking. In the proper calculation of this difference it must be remembered that the correlations for egg production is for the twelve month period where the production for the individual month correlation only contributes one-twelfth to the total annual egg production while that for the milk production contributes about one-fifth to the total production of the five lactations. The correlation would therefore be expected slightly larger for the milk production. This increased size of the milk correlations over the egg correlations is very small relative to the whole difference as the confirmatory results of table 1 shows. The correlations for the milk production of the successive lactations, therefore, represent in concrete terms that a greater reliance may be placed in the milk records of one lactation as measuring the cow's capacity than can be placed in the monthly egg records as measuring the hen's capacity for annual production. Such being the case, if we generalize this conclusion in its ultimate terms, the causative mechanism behind milk production works with greater fineness and precision than does the mechanism for egg production. Since this mechanism seems in its broadest sense to be of hereditary origin in the two cases, it follows that in the cow this hereditary complex is less influenced in its action by environment than is the action of the material stuffs of the fowl for egg production.

PRACTICAL ASPECT OF THE CORRELATIONS FOR MILK PRODUCTION OF ONE LACTATION RECORD WITH ANOTHER LACTATION RECORD.

The constants deduced in table 4 have a good deal of practical value to the dairyman and to the student of farm manage-

ment. To illustrate, suppose a herd which has 1000 two year olds who have just completed their first lactation is chosen at random. The manager of this herd will wish to know what animals to save for future lactations and the student of farm management desires to know what may be expected for the total production of the animals to enable him to determine the plane to which the herd should be culled for the greatest profit to the owner.

Perhaps one of the easiest ways to table the necessary information for its readiest uses is to have the summation of both the number of cows and their expected total production. This summation to be from both ends of the range of milk produced. The data for such a comparison are given in table 5.

If all the cows in this herd are kept to their sixth lactation the average production for each cow for the five lactations would be 25,070 pounds of milk. Noting the summed number of cows in column four if the 217 poorest producers are culled from the herd the cows left in the herd will produce on an average 26,408 pounds or an average 5,389 pounds more milk than the culled cows. Again if the dairyman decides to cull out 543 of the thousand animals the production of the 457 remaining will be 28,192 pounds or 5,747 pounds more than the culled cows on the average for the summed productions for the five lactations.

As the records dealt with in this paper are all for the first eight months of lactation it follows that most cows will extend beyond this limit and produce more milk. In using this table to determine what cows may be kept profitably, this fact should be kept in mind. If the dairyman has determined the complete cost of producing his milk a knowledge of the price he receives for it will allow him to determine at once from column three what cows he should keep in the herd.

In the bulletin following this, the relation of the butter-fat percentage to the age of the cow will be analyzed using the records for this herd.

TABLE 5.

Actual Milk Production of One Thousand Two Year Old Cows and the Expected Five Lactation Yield for Any Division of That Herd or Per Cow for Any Division.

Actual Milk Production	Cows producing given amount	Expected five Lactation Yield	Summed Number of cows Lowest to Highest Production	Expected summed 5 lactation yield for cows in herd lowest to highest production	Summed number of cows highest to lowest production	Expected summed 5 lactation yield for cows in herd Highest to lowest	Expected production per cow—Lowest to highest	Expected production per cow—Highest to lowest
1375 to 1625	1	14143	1	14,143	1000	25,069,737	14,143	25,070*
1625 to 1875	2	15221	3	41,355	999	25,050,000	14,822	25,076
1875 to 2125	5	16300	8	128,721	997	25,028,382	15,794	25,098
2125 to 2375	12	17378	20	335,173	992	24,941,016	16,734	25,146
2375 to 2625	23	18457	43	753,397	980	24,734,564	17,649	25,240
2625 to 2875	38	19535	81	1,498,071	957	24,316,340	18,538	25,401
2875 to 3125	57	20614	138	2,681,904	919	23,571,666	19,400	25,644
3125 to 3375	78	21692	217	4,381,681	862	22,387,833	20,229	25,979
3375 to 3625	98	22770	314	6,604,300	783	20,688,056	21,019	26,408
3625 to 3875	112	23849	426	9,266,303	686	18,465,437	21,761	26,926
3875 to 4125	118	24927	543	12,195,510	574	15,803,438	22,445	27,524
4125 to 4375	114	26006	657	15,161,471	457	12,874,227	23,063	28,192
4375 to 4625	102	27084	759	17,922,976	343	9,908,266	23,604	28,920
4625 to 4875	84	28163	843	20,281,602	241	7,146,761	24,056	29,698
4875 to 5125	63	29241	906	22,121,166	157	4,788,135	24,416	30,517
5125 to 5375	43	30320	949	23,422,180	94	2,948,571	24,683	31,371
5375 to 5625	26	31398	975	24,247,950	51	1,647,557	24,864	32,254
5625 to 5875	14	32477	989	24,711,391	25	821,787	24,974	33,163
5875 to 6125	7	33555	996	24,936,881	11	358,346	25,032	34,096
6125 to 6375	3	34634	999	25,029,352	4	132,856	25,057	35,054
6375 to 6625	1	35712	1000	25,069,737	1	40,385	25,070*	36,058

*It will be noted that this figure does not correspond exactly with that of table 4.

BULLETIN 290

THE VARIATION OF BUTTER-FAT PERCENTAGE WITH AGE IN JERSEY CATTLE.*

By John W. Gowen.

SUMMARY

This paper deals with the variation of butter-fat percentage for a pure bred herd of Jersey cattle. The mean butter-fat percentage for this herd is $5.2260 \pm .0073$. The comparison of the butter-fat percentage of the milk of 28 different breeds of cattle shows this mean butter-fat percentage as high as that for any breed. The range of variation of these means for the different breeds is between 3.05 to 5.12. The frequency distribution for this range is bimodal one mode occurring at about 3.7 per cent and the other at about 5.0 per cent.

When the variability of the butter-fat percentage is compared with that of the other milk constituents it is found that the variation of the butter-fat percentage from cow to cow is about twice as much as is the variation of the solids-not-fat percentage.

Comparing the variation of the percentages of the different parts of the egg with the variation of the butter-fat percentage it is found that the percentage of yolk and of shell vary to the same degree as the butter-fat percentage but that the percentage of albumin has only half the variation of the butter-fat percentage.

There is a slight negative correlation ($-0.1126 \pm .0161$) between the age of the cow and the butter-fat percentage which the cow will produce. Described in word this correlation states that for each increment added to the age of a cow there is a

*This paper is an abstract of a longer paper on "Studies in Milk Secretion VI. On the Variations and Correlations of Butter-Fat Percentage with Age in Jersey Cattle," published by the same author in Genetics, May 1920. All literature citations should be made to this complete paper.

slight but consistent decrease in the butter-fat percentage which her milk will contain.

The problems of milk secretion taken from their economic and scientific aspects may be said to be twofold, the first phase of the subject dealing with the problems connected with the production of the quantity of milk, the second phase considering the quality or amount of the constituents per unit volume of the milk. This second phase to the minds of most people has come to mean for milk production the amount of butter-fat per unit volume of the milk or the percentage of this butter-fat.

In studies in milk secretion V of this series of papers the subject of the variations and correlations of milk secretion with age was examined analytically. In this paper it is proposed to deal with the normal fluctuations and associations of the butter-fat percentage for the milk of the same cows used in the preceding study.

The theorem chosen is a small part of that greater problem which has come to be known under the title of developmental mechanics. If a group of like animals are measured for any character and the measurements brought together in a curve representing the individuals in the group, the position of any individual in the curve and the shape of the curve itself are the functions of the two basic variables given such prominence by the work of Galton, environment and heredity. This environment may play a larger or a smaller part in its influence on the character. In most inheritance studies of what might be called qualitative characters, commonly classified as the chemist does in analyzing a chemical compound for its constituent elements as barium present or barium absent, the environmental differences cause little variation in the somatic appearance of the character. In other words put in quantitative terms coefficient of variability of the character is low or as the physicist says the character is constant. The place of the individual in a curve then is due largely if not entirely to heredity.

In the so called quantitative characters the conditions are reversed to a certain extent. The superimposed variability of the conditions under which the organism exists play their part along with heredity in determining the place in the variation curve that the individual will take. Clearly in a study of the

hereditary nature of such a quantitative character a knowledge of its variation is essential to any adequate study of the subject. Before the milk production or butter-fat percentage of a heifer and an age cow are compared we must know what has come between for this may be and often is a part of heredity itself.

What these investigations, the first on milk production and the present one on butter-fat percentage, have attempted to do is to analyze the individual variations of the individuals in one curve in terms of their component parts.

Material and Methods.

The material and methods used are the same as those of the previous paper save that certain of the cows kept in the early history of the herd were not tested for butter-fat. The number remaining after these were discarded were 1713 with complete eight months butter-fat percentage records. Throughout this study all of the records are for the first eight months of the lactations that extend at least through the ninth month. For the benefit of those who are unfamiliar with the previous paper, that part of the introduction significant to the data and its manner of collection is quoted.

"The data are exceptional in the following ways: (1) The records extend back to the year 1897 when the herd was organized; (2) the animals are practically all straight island stock; (3) they have been under the oversight and direction of one manager since 1901; (4) exact records are kept of the milk production, butter-fat per cent and butter-fat; (5) many of the individual animals have records for several different lactations.

The elimination of variation caused by varying the five factors above in the records of cows to be used for exact analysis of the laws of milk and butter-fat production is important, as it has been often shown that such differences can influence the herd's production. It is obvious that these records are free from such variables. They constitute a homogeneous group of data representing the island Jersey under constant conditions of management and climate.

The data used for study are all from normal healthy cows. Two diseases have been present in the herd, tuberculosis and abortion. The tubercular animals were all eliminated early in

the herd's history by the use of the tubercular test. All records from animals which were proven to be tubercular or which aborted were not used. Records from animals normally healthy but sick during a given lactation were not used. All of the cows have been kept in climatic conditions similar to those of western Virginia.

A word as to the method of keeping the data and its transfer to this Station. All records are made at the time of milking on the dairy milk sheet for the given cow which are kept in the barn. The milking taking place twice a day the records are for night and morning. The weekly production taken from these sheets is transferred to the herd ledger by a trained bookkeeper. The total production for a given month is found together with the yearly production by adding the weekly totals. All records are recorded to pounds and tenths. The cows are tested bimonthly by the Babcock test and the percentage of butter-fat is recorded beside its corresponding monthly milk yield. All weighings and readings are recorded immediately after they are made so there is little chance of inaccuracy. From these records the author has extracted 1741 complete 8 months records of healthy cows for milk production. Of these 1741, 1713 have records for the butter-fat per cent. The weighted monthly averages of the bi-monthly test have been used to obtain the weighted 8 months average for the 8 months lactation period chosen for study."

VARIATION OF FAT PERCENTAGE IN JERSEY MILK WITH THE AGE WHEN THE TEST WAS MADE.

The records for the mean butter-fat percentage for the 8 months of lactation have been calculated by the author for all cows and for each lactation.

The chief physical constants for these data are presented in Table 1. The four constants presented are the mean, standard deviation, coefficient of variation and skewness.

Several features of general interest concerning butter-fat secretion are evidenced by this table. These points can only be touched hurriedly as it is planned to take up most of them individually in later sections of this paper.

TABLE 1.

Constants of Variation of Butter-Fat Percent for the Successive Ages at Test in Jersey Milk. (8 Months Lactation Period.)

Age at test	Mean	Standard Deviation	Coefficient of Variation	Skewness
2 yrs. 0 mo. to 3 yrs. 0 mo.	5.2635±.0183	0.4662±.0129	8.8581±.3473	+0.1333±.0490
3 yrs. 0 mo. to 4 yrs. 0 mo.	5.2777±.0204	0.4749±.0145	8.9976±.3909	+0.2635±.0556
4 yrs. 0 mo. to 5 yrs. 0 mo.	5.2759±.0196	0.4415±.0139	8.3680±.3744	+0.2744±.0583
5 yrs. 0 mo. to 6 yrs. 0 mo.	5.2345±.0187	0.4132±.0132	7.8938±.3644	--------------
6 yrs. 0 mo. to 7 yrs. 0 mo.	5.1875±.0216	0.4445±.0153	8.5686±.4191	--------------
7 yrs. 0 mo. to 8 yrs. 0 mo.	5.1697±.0223	0.4322±.0158	8.3599±.4359	+0.1047±.0732
8 yrs. 0 mo. to 9 yrs. 0 mo.	5.1553±.0249	0.4156±.0176	8.0619±.4359	—0.1357±.0718
9 yrs. 0 mo. to 10 yrs. 0 mo.	5.1668±.0353	0.4818±.0249	9.3259±.6875	—0.5656±.2963
10 yrs. 0 mo. to above	5.1339±.0288	0.4419±.0204	8.6073±.5647	--------------
Total Population	5.2260±.0073	0.4492±.0052	8.5950±.0995	+0.1003±.0209

The mean butter-fat percentage is the highest in the early ages at which the Jersey cow's mammary gland is functioning. From this high point the percentage of this butter-fat declines irregularly toward the older years of the cow's life. The lowest percentage is reached when the cow is over ten years of age. The difference between the highest mean value of the percentage of butter-fat occurring at three years old and the lowest mean value at ten years and older (5.2777±.0204 and 5.1339±.0288) is 0.1438±.0354 or the difference is 4.05 times the probable error. Such a difference while only mediocre, is likely to be significant. The point will be discussed later in connection with other data. The mean percentage of butter-fat of these Jersey cows (5.2260±.0073) agrees fairly well with that on other Jersey data (5.12) published by the author in table 2 of a previous bulletin. As the data on which the 5.12 percentage was based, included a wide variety of conditions, climate, management, etc. it would appear reasonable to suppose that this figure represents a fair average for the Jersey breed. If such is in fact the case the average production of the Jerseys included in the herd studied are above those of the breed as a whole in butter-fat percentage contained in their milk. The difference is slight in absolute amount, however.

If we examine the butter-fat concentration of the milk of the various breeds summarized in the table referred to above, we see that the Jersey stands at the top of the list of these

twenty-eight herds as to the amount of butter-fat produced in its milk. The variation of this average butter-fat is between 3.05 and 5.12 per cent and the Jerseys are more than two per cent greater in mean butter-fat percentage than are the lowest cows of the species. It is especially instructive to study the distribution of these tests a little more closely. For this purpose the tests were grouped into two-tenths per cent intervals. Such a distribution gives some appreciation of the hereditary factors which may be expected to occur in the given breed. The results of such a grouping show that there are two breeds the Jersey and the Guernsey at the top of the scale for the butter-fat concentration of their milk. The percentage is around 5 per cent. In the other group are included the breeds of cattle with a mean butter-fat percentage around 3.7. Between these two groups there is a distinct break between a mean percentage of 4.2 and 4.6. Such a break is highly suggestive of an hereditary difference of at least one unit between these breeds. In this connection the range or spread of the frequency distributions taken for each of these high and low test groups is of interest. Taking the data from the Jerseys of this paper and the Holstein-Friesian of the above mentioned paper the range of butter-fat for the first is 3.65 to 6.95 while that for the Holstein-Friesian is 2.4 to 4.8. As the two frequencies are not very far from normal and as what skewness there is is plus, it follows that the overlap of these curves constitutes only a small area of the total covered by them. The differences of the two breeds are therefore quite distinct. The differences in the scatter of the two groups is also significant as measured by the standard deviation. The standard deviation for the Holstein-Friesian group is $0.318 \pm .004$ and that of this Jersey group is $0.449 \pm .005$ or the difference and the probable error are $0.131 \pm .006$. Absolutely considered the higher fat test cows are more variable than the lower butter-fat percentage cows. In the Jersey or highest group no influence of age on the standard deviation appears to exist.

The coefficient of variation is worth especial study as it gives us in comparable terms the relation between the standard deviation of a distribution and its mean. For our problem the conclusions to be derived from it are not, unfortunately, so straight forward as we are dealing with the index, butter-fat

percentage. Reflection on the purpose of the coefficient of variation will make clear that the use of coefficients of variation comes in ridding the coefficient of the terms in which the data are recorded. In other words the coefficient is made a pure number. This is also just what an index does, consequently the use of a coefficient of variation of an index is somewhat like calculating the variation of a pure number. How much this influences the conclusions to be derived from such coefficients of variation is a matter of some doubt. That there is some influence is known; it is, however, altogether probable that this disturbance is not so great but what some conclusion may be drawn from the calculated coefficients of variation even admitting these disturbances.

The need for such a comparison become especially clear in our data on butter-fat percentage. Here the character studied is the concentration of the butter-fat in the milk and not the total mass or pounds of this fat secreted for a lactation. Information is desired on the variation of the functioning of the cells which secrete this concentrated fat emulsion in comparison with those of cells of the mammary secreting a low concentration of fat. Furthermore comparison data for the variation of the ability of other glandular cells in their secretory activity is desirable. For these reasons it has seemed best to present coefficients of variation for such data realizing in so doing that too wide conclusions cannot be drawn from them. The data for this comparison are given in Table 2. In this table are also included, to save the table space, the calculated skewness of the frequency distributions as these data will be used shortly.

The standard deviations of the butter-fat percentage of the milk produced by the four breeds, Jersey, Guernsey, Holstein-Friesian and Ayrshire shows a relation to the mean concentration of this butter-fat, such that, the breeds producing the greatest concentration have a significantly larger variation than do the breeds whose milk contains less fat. The solids other than the butter-fat, contained in the milk of the Holstein-Friesian cows, show approximately the same standard deviation as does the butter-fat of this breed. Such mean solids-not-fat percentage of about two and one-half times the mean butter-fat percentage leads to a coefficient of variation of about half the size of that for the butter-fat percentage.

TABLE 2.

The Variation and Amount of Asymmetry of the Concentration of the Components of Known Secretions.

Character	Mean Percentage	Standard Deviation	Coefficient of Variation	Skewness	Source of Data
Milk					
Jersey butter-fat Percentage	5.22±.01	0.45±.01	8.60±.10	+0.10±.02	*This paper*
Holstein-Friesian butter-fat Percentage	3.44±.01	0.32±.00	9.23±.12	+0.15±.02	Gowen
Holstein-Friesian Solid-not-Fat Percentage	8.60±.01	0.34±.01	3.92±.11	+0.17±.05	Gowen
Ayrshire Butter-Fat Percentage	3.68±.01	0.32±.01	8.76±.17*	+0.16±.03	Vigor
Guernsey Butter-Fat Percentage	5.03±.00	0.48±.00	9.45±.01	+0.12±.01	Gowen
Egg of Domestic Fowl†					
Albumen Percentage	59.83±.04	2.75±.03	4.59±.03*	+0.27±.02*	Curtis
Yolk Percentage	30.00±.04	2.70±.02	8.99±.06*	+0.21±.02*	Curtis
Shell Percentage	10.13±.01	1.04±.01	10.30±.06*	+0.10±.02*	Curtis

*These constants were calculated by the author from the data presented by the different investigators whose papers are cited. The means and standard deviations cited from these authors have been checked by the author.

†The author is indebted to Dr. M. R. Curtis for the loan of the original data on which the calculations were based for the variation of the parts of the egg.

The standard deviations of the percentage constituents of the egg parts are all higher than those for the percentage constituents of the parts of the milk. Thus the standard deviations of the percentage of albumen in the egg is 2.75, that of the yolk is 2.70 and of the shell 1.04; whereas for the butter-fat percentage the standard deviations range from 0.32 to 0.48. This would seem to indicate a real difference in variability between the functioning of the gland cells of the udder of the cow and the oviduct of the hen. The mean percentage of the different parts of the egg are considerably larger than those of the milk parts, however. For the percentage of yolk and the percentage of shell the coefficients of variation agree well with those found for the variation of the butter-fat percentage. The coefficient of variation for the albumen does not agree with that of the butter-fat percentage but does agree with that of the solids-not-fat in the milk of the cow. In the formation of the egg of the domestic fowl it is well known that only certain cells can secrete a given substance. The similar variation of the protein containing solids-not-fat and the albumen portion of the egg and

the similar variation of the lipin portion of the milk the lipin portion of the egg calls attention to the lack of knowledge concerning the exact nature of this secretory activity of the mammary gland and the possibility that there may be two types of cells in this gland of separate and distinct function.

Returning to Table 1, no skewness is present in three of the nine distributions. In the remaining six distributions at the different ages there are four in which the skewness is plus and two in which the skewness is minus. The frequency distributions of butter-fat percentage at the first three years of the lactation life of the Jersey cow are skew in the plus direction. This skewness increases to the fifth year of lactation. At this age the curves for the butter-fat percentages are symmetrical. The minus skewness of the eight and nine years of age are quite unlooked for. Negative skewness is on the whole, rare. Why milk production at these ages should change to become minus and minus to as large an amount in the ninth year of age is not clear.

The general frequency distribution for the butter-fat percentage of Jersey milk has a plus skewness of rather small amount. The comparison of the skewness for this Jersey data with that of other breeds is given in Table 2. These data show that butter-fat percentage of the four breeds, Jersey, Holstein-Friesian, Ayrshire and Guernsey is plus and of small amount. The distribution of each breed have approximately the same numerical value for this constant.

Comparison of the skewness of the other milk solids with those of the butter-fat percentage distributions show these distributions are, within the limits of random sampling equal in their asymmetry.

The comparison of the skewness of the percentage composition of the parts of the egg reveals the fact that the skewness of the percentage of shell is of about equal amount with those of the different parts of the milk. The skewness of the percentages of yolk and of albumen are slightly greater than those of any of the butter-fat percentages contained in the milk of the different breeds. In comparison with their probable errors the difference between these values is in certain cases undoubtedly significant in other cases the significance of the data is not so clear.

The conclusion appears justified that the frequency distributions for butter-fat percentage in cow's milk are slightly asymmetrical and that this skewness is in the plus direction.

THE CORRELATION OF JERSEY 8 MONTHS BUTTER-FAT PER CENT WITH AGE OF THE COW AT COMMENCEMENT OF TEST.

Increase in age of the cow from the time she is a heifer to the time she is at her maximum productivity at 7 years has been shown to bring about a logarithmic increase in the quantity of eight months milk produced by that cow. The effect of increasing the age of the cow on the quality is of equal interest to the student of the physiological behavior of the mammary gland. The data for this comparison in the herd of pure bred Jersey cows with which this study deals are shown in Table 3.

TABLE 3.

Correlation Surface for Butter-Fat Percentage and Age at Test For Jersey Cattle. (Lactation Period 8 Months).

Age at Test	BUTTER-FAT % 3.50—3.65	3.65	3.80	3.95	4.10	4.25	4.40	4.55	4.70	4.85	5.00	5.15	5.30	5.45	5.60	5.75	5.90	6.05	6.20	6.35	6.50	6.65	6.80	6.95—7.10	Total
1:6— 2:0							1	3	2	3	3	3	7	7	3	4	1	1							38
2:0		1				4	11	12	13	24	35	37	42	25	10	13	10	5	5	2			1		250
2:6						1	3	1	3	5	7	7	6	3	2		3	3			1	1			46
3:0						3	6	5	12	11	18	34	15	19	16	6	8	1	1	1		1	1		158
3:6						1	3	9	4	13	13	10	7	6	7	3	3	1	2	2	2	1			87
4:0						1	2	5	12	18	15	15	18	13	13	9	4	3	2	1			1		132
4:6						1	2	6	9	14	12	15	11	8	8	3	6		1		2				98
5:0					1			7	11	9	18	13	14	14	10	6	3					1			107
5:6					2		4	9	5	15	13	21	14	13	7	4	5	1		1	1				115
6:0						4	3	6	6	12	10	13	9	13	2	5	3	1	1	1	1				90
6:6				1	1	2	3	6	9	11	18	13	14	8	8	3	2	3							102
7:0					1		4	3	11	10	6	12	16	5	5	2	3	2					1		81
7:6				2		2	3	6	6	12	13	16	12	11	1		3	3							90
8:0			1			1	5	4	7	3	11	10	10	10	3	1	4								70
8:6						2	3	6	1	7	6	11	8	8	1	2	1	1							57
9:0			1	1		2	1	3	1	6	3	4	11	5	2	6	2								48
9:6					1	3	1	3	4	3	4	3	3	8	2	1	1								37
10:0					1		1	1	4	4	2	4	3	6	1	1			1						29
10:6						1	1	3	1	3	1	3	4	2		1	1								21
11:0						1				1	3	4	5	1	1	1		1							18
11:6						1			1	2		6		1	1										12
12:0				2					1	1	1	1			1			1							8
12:6						1		1	2		2		1	1											8
13:0					1	1			1		1	2													6
13:6													1	1											2
14:0											1	1													2
14:6														1											1
15:0																									
15:6—16:0																									
Total		1	2	6	8	32	57	99	126	187	216	258	231	189	104	71	63	27	13	8	7	4	4		1713

The correlation and its accompanying constants for these two variables is shown in Table 4.

TABLE 4.

Constants Measuring the Intensity of the Association Between Age and Butter-Fat Percentage Found in the Eight Months Milk of Jersey Cows.

r	η	$\eta^2 - r^2$
$-0.1126 \pm .0161$	$0.1478 \pm .0159$	$0.0092 \pm .0031$

From these constants it is clear that there is a slight significant relation between the age of the cow and the concentration of the butter-fat contained in her milk. The value of η corresponds well with that of r except that it is different in signs as η by its derivation is a positive quantity. The regression is clearly a linear one as the values of the constants to measure the linearity ($\eta^2 - r^2$) are less than three times their probable error ($0.0092 \pm .0031$).

In comparison with the previous curves on the milk production for the same cows plotted on the same age basis the curve for the butter-fat percentage shows that while the milk production rises logarithmatically to a maximum and then falls off more slowly, the butter-fat percentage actually is slightly decreasing in this milk, as the age increases. This means that while the mass of butter-fat produced by a cow follows in general the same kind of function as does the milk, there is this difference; vs. the butter-fat relative to the milk is always decreasing slightly in amount.

This fact of a slight negative correlation and a consequent decline in the mean butter-fat percentage produced with the advancing age of the Jersey cow is interesting in comparison with the known facts for other breeds. As previously shown by the writer the correlation between age and butter-fat percentage for the year test Holstein-Friesian cows is $-0.0546 \pm .0181$. Vigor has shown the correlation between these same variables to be $-0.2744 \pm .0255$ for Ayrshire cattle (the author has

checked the results and found it correct). From unpublished data of the writer the correlation of advanced registry Guernsey cattle for these same variables is $-0.1174 \pm .0134$. The correlation for the Jersey is equal to $-0.1126 \pm .0161$. Two of these correlations are based on advanced registry data and may be considered as subject to a selective influence on the data. The distributions do not look as if such a disturbing factor had been present as there is no evidence of truncation and as shown in a previous part of the paper the frequency constants agree quite well with those of the Jerseys and Ayrshires known to be untruncated. It seems therefore that the constants above should be directly comparable as to the relation of age and buter-fat percentage of these breeds.

The Jersey correlation coefficients do agree very closely with those of the Guernseys. The Ayrshire do not agree at all with any of the other breeds for difference of the correlations of Ayrshire and Jersey is $0.1618 \pm .0301$ or 5.4 times its probable error. The multiple times the probable error is greater for the Holstein-Friesians. The difference of the Holstein-Friesian correlation from that of the Jerseys is probably not significant as it is only 2.4 times the probable error. The correlation for the Holstein-Friesian age and percentage of butter-fat produced is probably not significant.

The Ayrshire results are obtained under the conditions of Scotland whereas, the other results, are on cattle kept in this country. This may possibly account for the difference in influence of age on butter-fat concentration of Ayrshire cows as compared with these other breeds or it may equally well mean that the Ayrshires are innately different from the other breeds.

The correlation for the Holstein-Friesian in comparison with the correlation for the other breeds is small. It does show the same sign as the other correlations.

These considerations taken together lead to the following conclusion which may be expressed tentatively as follows: each increment of time added to a cow's life causes a slight decline in the concentration of butter-fat that the cow's mammary gland can secrete into the milk.

In the bulletin following this, the relation of the butter-fat percentage of one lactation to the butter-fat percentage of a subsequent lactation will be analyzed using the records from this same herd.

BULLETIN 291

THE CORRELATION BETWEEN THE BUTTER-FAT PERCENTAGE OF ONE LACTATION AND THE BUTTER-FAT PERCENTAGE OF SUCCEEDING LACTATIONS IN JERSEY CATTLE*

BY JOHN W. GOWEN.

SUMMARY

This bulletin presents a study of the accuracy with which the butter-fat percentage of one lactation predicts the butter-fat percentage of a subsequent lactation for a pure bred herd of Jerseys under uniform farm conditions. The correlation coefficients describing this relation range from $+0.6781 \pm .0310$ to $+0.2470 \pm .0640$. The numerical value of these correlation coefficients signifies that with a fair degree of accuracy the butter-fat percentage of one lactation measures the probable butter-fat percentage of a subsequent lactation.

The mean of these correlation coefficients for butter-fat percentage of one lactation with another was $+0.5215$. The mean of the milk production of one lactation with another was $+0.5352$. There is consequently no difference in the relative accuracy of the prediction of milk yield or butter-fat percentage from one lactation to another.

The mean value of the correlation coefficients for the monthly egg yield of White Leghorn pullets with their year egg yield was $+0.446$. Comparison of this correlation with those given above makes it seem that greater dependence may be placed in the record for milk yield or butter-fat percentage of a cow as a measure of future production than can be placed

*This paper is an abstract of a longer paper on "Studies in Milk Secretion VI. On the Variations and Correlations of Butter-Fat Percentage with Age in Jersey Cattle," published by the same author in Genetic, May 1920. All literature citations should be made to this complete paper.

in the monthly egg record of a hen as a measure of her year record.

The relation of the average butter-fat percentage of one lactation with the butter-fat percentage of five lactations is determined. These correlation coefficients range from $+0.784 \pm .028$ to $0.862 \pm .018$. Such high values indicate that with slight inaccuracy the butter-fat percentage of one lactation predicts the butter-fat percentage of the first five lactations of a cow's life.

Table 4 furnishes a ready means of determining from the butter-fat percentage of the first lactation what the butter-fat percentage of the first five will be for a Jersey herd of similar butter-fat percentage to the herd here studied.

In a preceding bulletin the discussion of these data was directed toward the analysis of the influence of age on the percentage of butter-fat produced in a given lactation and the variability of this butter-fat percentage with age. In the present bulletin the phase of the problem dealing with butter-fat percentage of one lactation in relation to that of another lactation will be considered.

Little or no analysis based on concrete data has been made on this problem, yet obviously on a knowledge of these relations depend the justification for many of the practices now extant in dairy husbandry as well as laying the foundation for the solution of many problems connected with the secretion of butter-fat percentage itself. The existing information concerning butter-fat secretion is largely empirical. It is commonly said that the great butter-fat producing machines of today are due to these cattle breeders using such methods. In the widest sense this is no doubt true although such a mode of procedure tells us nothing about the biological factors underlying the advance in butter-fat percentage, or the laws by which it is governed. In such cases chance and luck play a very important part in the improvement. It is in the removal of these disturbing factors and making the improvement less haphazard that exact numerical analysis find their place. The solution of the problems connected with butter-fat production are complex and need to be approached from many angles. This section of the present investigation was undertaken in the hope that some knowledge

of the intra-individual variation with regard to the relative concentration of this butter-fat from lactation to lactation would throw some definite light on these problems. The homogeneous nature of the material is especially favorable to this problem.

Naturally the problem resolves itself into a study of the relative strength and precision of action of the inherited complex possessed by the cow working in conjunction with and in opposition to the environmental changes. If heredity plays a large part in the production of a cow the position of the cow in the frequency curves discussed in the earlier part of the paper will remain approximately the same from lactation to lactation; if on the other hand heredity of butter-fat production is weak in comparison with the influence of the shifts in environment, the position in our frequency curves of the cow will change materially from lactation to lactation. The preliminary steps in the analysis of this problem included a study of the mean butter-fat percentage for each age and the standard deviations of this for the different ages.

The conclusion which may be drawn from this study of the means, standard deviations and coefficients of variation is that no selection of cows for future milkers on the basis of their butter-fat percentage in previous lactations has been practiced at any time in the herd's history. This important conclusion regarding the data reflects back on the conclusion drawn from the studies of the earlier paper* as those conclusions are freed from the one possible criticism that selection of the best producing animals, to be kept for the milkers in later life, by the records made while they were young, has materially influenced the general applicability of the results of this study to the herd of Jersey Cattle as a whole.

THE CORRELATION OF THE BUTTER-FAT PERCENTAGE FOR EIGHT MONTHS' MILK YIELD AT A GIVEN AGE WITH THE LIKE BUTTER-FAT PERCENTAGE AT ANY OTHER GIVEN AGE.

The homogeneous nature of the records established by the previous analysis, the data may now be used for the correlations

*Gowen, John W., 1920. The Variation of Butter-Fat Percentage with Age in Jersey Cattle. In Annual Report of the Maine Agricultural Experiment Station for 1920. pp. 132-144.

themselves knowing that the data on which these correlations are based are such that the values of the correlations are their true values.

TABLE 1.

Coefficients of Correlation for Butter-Fat Per cent of a Given Year when Correlated with Other Given Years.

AGE CORRELATED.

Age with which correlated	2:0—3:0	3:0—4:0	4:0—5:0	5:0—6:0
2:0—3:0	--------------	+0.5277±.0368	+0.5288±.0390	+0.5846±.0382
3:0—4:0	+0.5277±.0368	--------------	+0.6071±.0349	+0.5836±.0384
4:0—5:0	+0.5288±.0390	+0.6071±.0349	--------------	+0.6781±.0310
5:0—6:0	+0.5846±.0382	+0.5836±.0384	+0.6781±.0310	--------------
6:0—7:0	+0.5956±.0407	+0.5861±.0426	+0.5236±.0460	+0.5529±.0417
7:0—8:0	+0.6068±.0452	+0.2470±.0640	+0.5668±.0447	+0.4830±.0480
8:0—10:0	+0.5695±.0468	+0.4311±.0533	+0.4475±.0498	+0.5638±.0382
10:0 and above	+0.5739±.0787	+0.5250±.1121	+0.5163±.0674	+0.4138±.0747

Age with which correlated	6:0—7:0	7:0—8:0	8:0—10:0	10:0 and above
2:0—3:0	+0.5956±.0407	+0.6068±.0452	+0.5695±.0468	+0.5739±.0787
3:0—4:0	+0.5861±.0426	+0.2470±.0640	+0.4311±.0533	+0.5250±.1121
4:0—5:0	+0.5236±.0460	+0.5668±.0447	+0.4475±.0498	+0.5163±.0674
5:0—6:0	+0.5529±.0417	+0.4830±.0480	+0.5638±.0382	+0.4138±.0747
6:0—7:0	--------------	+0.5594±.0420	+0.4678±.0434	+0.3196±.0788
7:0—8:0	+0.5594±.0420	--------------	+0.6004±.0349	+0.4137±.0659
8:0—10:0	+0.4678±.0434	+0.6004±.0349	--------------	+0.5294±.0436
10:0 and above	+0.3196±.0788	+0.4137±.0659	+0.5294±.0436	--------------

Table 1 gives the correlations and their probable errors for all ages at which the lactation records were divided. The vertical columns as in the preceding tables for the other constants of the correlation surfaces give the correlations of the butter-fat percentage of the ages heading the column with the butter-fat percentage at the ages indicated on the left hand margin of the table. As will be noted the correlations necessary to give the complete set of correlations for any age are repeated e. g. the correlation of 2 years butter-fat percentage with that at 3 years is +0.5277±.0368 and appears in the two year column on line with the three year age. The correlation of the three years

butter-fat percentage with that of the two years will, of course, be the same (0.5277±.0368) and is repeated in the three year column on the line with the two year age. Such an arrangement facilitates the grasping of the complete picture of the relation between the yield of a given age and that of any other year, as each column represents the correlation coefficients of that year with the other years.

The largest of these correlation coefficients for the butter-fat percentage of one lactation in comparison with that of another is +0.6781±.0310 for the lactation at four years old and at five years old. The lowest correlation coefficient is +0.2470 ±.0640 for the comparison of the butter-fat percentage of the three year olds with that of the seven year olds. All of these correlations are plus. There was no correlation out of the fifty-six determined which was not significant. Such high correlations point to a regulatory mechanism behind the mammary function which governs, within certain limits, the concentration of butter-fat which a given cow is able to secrete into her milk from one lactation to another. In other words the correlations of butter-fat percentage of a given aged cow with that of the other ages at which this cow may have other lactation records are approximately of the same values throughout.

The average level of the correlations for butter-fat percentage of a lactation of a given age with those at any other age is of especial interest to the dairyman since the size of the correlation is the index by which he may choose the lactation on which to base the selection of animals to remain in the herd as future milkers. The averages of these correlations have accordingly been made. The highest average correlation coefficient is for the butter-fat percentage of the lactation commencing between the ages two years to three years (0.5696). The next highest average correlation coefficient is for the four year age (0.5520). The five year ages is third (0.5514), the eight and nine year age is fourth (0.5156). The other ages at lactation follow in the order, six, three, seven, and ten and older years. The differences in these correlations are of only doubtful significance so that no conclusion as to the relative merit of the use of one lactation over that of another as a basis for selection of animals to remain in the herd, can with certainty be made. Further from the theoretical side no conclusion can be drawn from these figures as to any

differential action of the mechanism or effect of environment on the milk production and butter-fat percentage at these different ages. They do, however, lead to the important practical conclusion that a cow commencing her lactations as a two year old with a high butter-fat percentage may be expected to duplicate this relatively high performance within a small error in the next and succeeding lactations. The first lactation records as to the butter-fat percentage that a given cow will produce, are a good index of what may be expected in future years of that cow, as will be shown in a subsequent section. The selection of cows to remain in the herd on the basis of these records is profitable to the dairyman.

The comparison of these correlations with those on milk production for the same date using the same divisions is of considerable interest as showing the relative strength by which one lactation governs the future production of another lactation. Table 2 gives this comparison for the average unweighted coefficients of correlation for the records of each age with the records made at another age.

TABLE 2.

Average Coefficients of Correlation for Lactation Records Made at a Given Age and Lactation Records Made at Other Ages for Milk Production and Butter-Fat Percentage.

Age at which given record is made	Coefficient of Correlation		Difference Butter-Fat Percentage Milk Production
	Butter-Fat Percentage	Milk Production	
2 years to 3 years	+0.5696	0.5491	.0205
3 years to 4 years	.5011	.5694	—.0683
4 years to 5 years	.5526	.5060	.0466
5 years to 6 years	.5514	.5735	—.0221
6 years to 7 years	.5150	.5661	—.0511
7 years to 8 years	.4967	.5501	—.0534
8 years to 10 years	.5156	.5077	.0079
10 years and older	.4702	.4597	.0105
Average of records at all ages	.5215	.5352	—.0137

These correlation coefficients range in value from +0.4702 to 0.5696 for the butter-fat percentage and from +0.4597 to 0.5694 for the milk production. The average value of the butter-

fat percentage correlation coefficients is +0.5215 and the average value of the milk yields is +0.5352.

Of the sixteen average coefficients of correlation four of those for the butter-fat percentage are higher than those for the milk yield and four of them are lower.

The greatest difference of these coefficients is —0.0683. The difference of the average values is —.0137. From the numbers involved it seems probable that these differences are so small as not to be significant. Such being the case it follows that the relative accuracy in the use of one lactation record to predict the expected record of another lactation is approximately the same for the butter-fat percentage and for the milk yield. In other words the governing power (presumably the complex given the animal through its inherited factor for these two characters) works with about the same accuracy (as measured by its performance) from lactation to lactation. This by no means would necessarily mean that the inheritance of these two characters is the same; in fact in all probability high milk production is governed more by dominant factors than is high butter-fat percentage. It only means that these factors once given an animal hold it to the same relative level from lactation to lactation.

If we make the point of environment, transfer our reasoning to the race of Jersey Cattle with which we are dealing, these records of the individuals in this race show a distinct differentiation. The high individuals tend to remain high the low individuals low with respect to their butter-fat percentage just as they also do with respect to their quantity of milk. Such a difference can bespeak for but one thing the animals in this race are innately differentiated with regard to their capacity to secrete a high concentration of butter-fat into their milk as well as they are for the capacity to secrete the quantity of milk.

Only one other economic product has been dealt with quantitatively by the correlation method. The correlation coefficients in this case deal with the relation of the monthly egg production to the other eleven months of the year.

The correlations for these ovulation records range from $+0.240\pm.033$ to $+.573\pm.023$. The range for the correlations of butter-fat percentage is $+0.2470\pm.0680$ to $+0.6781\pm.0310$. The range in these butter-fat percentage correlations is greater than that for the ovulation records of the White Leghorn hen.

The mean coefficient of correlation for these ovulation records is +0.446. This mean coefficient of correlation is consequently, slightly below that for butter-fat percentage (0.5215) the difference being 0.0755. This difference, on the face of it, would seem to indicate a greater dependence may be placed in the record of the butter-fat percentage of a known lactation as to the future butter-fat percentage in a given cow's milk than can be placed in a knowledge of a month's egg production to determine the future production of the hen. The difference is not great, however, and may not be statistically significant.

CORRELATION BETWEEN THE MEAN BUTTER-FAT PERCENTAGE OF THE FIRST FIVE LACTATIONS AND THE MEAN BUTTER-FAT PERCENTAGE OF THESE INDIVIDUAL LACTATIONS.

Of perhaps even more interest physiologically and practically is the correlations of the butter-fat percentage of one lactation with the butter-fat percentage as determined for a number of lactations. For this purpose certain of the records on which the correlations of Table 1 were based, were chosen for this purpose. These records included the first five lactations for the cow's life. The correlations and other constants for these are given in Table 3.

Table 3 shows that the standard deviation of the butter-fat percentage for the mean of the five lactations in these 88 cows is lower than the standard deviation of these cows for any lactation. The coefficient of variation for the five lactation average butter-fat percentage is consequently lower than the coefficient of variation for the individual lactations. The mean coefficient of variation for the individual lactations is 9.03. This mean value is 1.38 greater than is the coefficient of variation for the five lactation butter-fat percentage. This difference appears to be slightly significant indicating a less variability for the butter-fat percentage over long periods than over a period so short as one lactation.

The correlation coefficients for the relation of the individual lactations butter-fat percentage for the five lactations are all high correlations as the run of correlations for this kind of data go. Compared with the similar data on milk production the average correlations for milk production are $\pm$0.818 and for

butter-fat percentage ±0.827. The value of the correlation coefficients are so high in each case that the average milk production or butter-fat percentage over a number of lactations can quite accurately be predicted from the productions obtained for any lactation.

TABLE 3.

Correlations and Constants for Butter-Fat Percentage over a Number of Lactations and the Butter-Fat Percentage for the Individual Lactations.

Age when lactation commenced	Mean Butter-Fat Percentage	Standard Deviation for butter-fat Percentage	Coefficient of Variation of the butter-fat percentage
2 years to 3 years	5.245±.035	0.491±.025	9.35±.46
3 years to 4 years	5.227±.035	.485±.025	9.29±.46
4 years to 5 years	5.291±.036	.502±.026	9.48±.46
5 years to 6 years	5.225±.033	.462±.023	8.83±.46
6 years to 7 years	5.177±.031	.425±.022	8.20±.41
Five lactation butter-fat percentage	5.216±.029	.399±.020	7.65±.39

Age when lactation commenced	Correlation of individual lactation records and the record for the five lactations	Correlation Ratios for individual records and the record of the five lactations	Regression Equations for the five lactation butter-fat percentage as calculated from any of the given lactations
2 years to 3 years	+0.797±.026	0.827±.023	$B_T = 1.819 + .648b_2$
3 years to 4 years	.836±.022	.855±.019	$B_T = 1.621 + .688b_3$
4 years to 5 years	.862±.018	.876±.017	$B_T = 1.591 + .685b_4$
5 years to 6 years	.857±.019	.873±.017	$B_T = 1.349 + .740b_5$
6 years to 7 years	.784±.028	.815±.024	$B_T = 1.406 + .736b_6$
Five lactation butter-fat percentage			

If it is admitted that there is a regulatory mechanism controlling the amount of milk produced by a cow in any lactation as it seems that it must be admitted from the evidence of a particular gland for its secretion, etc; then the large size of the correlations indicate clearly that this mechanism is quite accurately working in governing the relative amount of milk a cow will produce from lactation to lactation.

The precision of action of this mechanism for the secretion of butter-fat in a given cow's milk is greater than is the precision of action of the ovary of a hen in secretion of eggs as may be seen from the data of Harris and Blakeslee. For the White

Leghorn pullets the correlation of their monthly productions with their annual production ranges from $+0.373 \pm .030$ to $0.695 \pm .018$. The range of the correlations for butter-fat percentage is $0.784 \pm .028$ to $0.862 \pm .018$. The mean correlation coefficients stand in the relation 0.556 to .827 or 1 to 1.49.

PRACTICAL ASPECTS OF THE CORRELATIONS FOR BUTTER-FAT PERCENTAGE OF ONE LACTATION WITH THE BUTTER-FAT PERCENTAGE OF THE FIRST FIVE LACTATIONS.

As many of these results have a highly practical bearing it may be well to illustrate one of the uses to which they may be put. The question of what animals shall be saved for milk production and the perpetuation of the herd is a constantly recurring one in dairy practice. The correlations just deduced in Table 3 show that the basis of this selection should be the records of the previous lactation. Suppose the herd is composed of 1000 cows which have just completed their first lactation. The equation for this curve

$$y = 17.8901 \left(1 + \frac{x^2}{3.9271}\right)^{-9.6974} e^{5.2895 \operatorname{Tan}^{-1} \frac{x}{1.9817}}$$

allows the calculation of the distribution of these one thousand cows as shown in the second column of Table 4. From the eight months butter-fat percentage Table 3 gives the equation to determine the expected mean butter-fat percentage for the first five lactations. The equation is

$$B_T - 1.819 \pm .648 b_2$$

Where B_T is equal to the butter-fat percentage of the first five lactations and b_2 is the butter-fat percentage for the first lactation.

The data may be tabled for most easy reference by summation of the number of cows from both ends of the distribution and tabling the butter-fat percentage. This has been done for Table 4.

TABLE 4.

Actual Butter-Fat Percentage of One Thousand Two Year Old Cows and the Expected Five Lactation Butter-Fat Percentage for any Division of that Herd or per Cow for Any Division of It.

Actual Butter-Fat Percentage	No. of cows with given butter-fat percentage	Expected Butter-Fat Percentage for the first five lactations	No. of cows summed lowest to highest butter-fat percentage	No. of cows summed highest to lowest butter-fat percentage	Expected average butter-fat percentage —lowest to highest	Expected average butter-fat percentage —highest to lowest
3.75—3.85	1	4.281	1	1000	4.28	5.23
3.85—3.95	2	4.346	2	999	4.32	5.23
3.95—4.05	3	4.411	5	998	4.37	5.23
4.05—4.15	5	4.476	10	995	4.42	5.23
4.15—4.25	7	4.541	17	990	4.47	5.24
4.25—4.35	11	4.605	28	983	4.53	5.24
4.35—4.45	17	4.670	45	972	4.58	5.25
4.45—4.55	25	4.735	70	955	4.64	5.26
4.55—4.65	34	4.800	104	930	4.69	5.27
4.65—4.75	45	4.865	149	896	4.74	5.29
4.75—4.85	56	4.929	205	851	4.79	5.31
4.85—4.95	66	4.994	271	795	4.84	5.34
4.95—5.05	75	5.059	345	729	4.89	5.37
5.05—5.15	80	5.124	426	655	4.93	5.41
5.15—5.25	82	5.189	508	574	4.97	5.45
5.25—5.35	80	5.253	588	492	5.01	5.49
5.35—5.45	75	5.318	664	412	5.05	5.54
5.45—5.55	68	5.383	731	336	5.08	5.59
5.55—5.65	59	5.448	790	269	5.11	5.64
5.65—5.75	49	5.513	839	210	5.13	5.69
5.75—5.85	40	5.577	880	161	5.15	5.74
5.85—5.95	32	5.642	911	120	5.17	5.80
5.95—6.05	24	5.707	936	89	5.18	5.86
6.05—6.15	18	5.772	954	64	5.19	5.91
6.15—6.25	14	5.837	968	46	5.20	5.97
6.25—6.35	10	5.901	978	32	5.21	6.02
6.35—6.45	7	5.966	985	22	5.22	6.08
6.45—6.55	5	6.031	990	15	5.22	6.13
6.55—6.65	4	6.096	994	10	5.22	6.18
6.65—6.75	3	6.161	996	6	5.22	6.23
6.75—6.85	2	6.225	998	4	5.23	6.27
6.85—6.95	1	6.290	999	2	5.23	6.32
6.95—7.05	1	6.355	1000	1	5.23	6.35

The first column of the table gives the butter-fat test of the milk produced in the first eight months of lactation for two-year old cows. The second column gives the distribution of a herd of one thousand two year old cows of like constitution to the pure bred Jersey cattle which are being studied. All the calculations have been carried to several decimal places beyond the tabled constants as only by so doing would the results have been more than approximately correct. The third column gives

the butter-fat percentage to be expected for the first five lactations milk of cows which have the butter-fat percentage of those shown in the first column.

Noting the expected butter-fat percentage of the highest and lowest tested cows in this column it is seen that those cows which test very low in butter-fat (3.75 to 3.85) in their first lactation on the average increase 0.581 per cent of butter-fat for the milk of their first five lactations; for the highest butter-fat test cow in their two year lactations the butter-fat percentage for their first five lactations is on the average 0.645 per cent of butter-fat lower than is the test for the first lactation test.

The third and fourth columns give the summations of the number of cows from the lowest butter-fat test to the highest and from the highest butter-fat test to the lowest. The last two gives the butter-fat test expected for these one thousand two year old Jersey heifers when the herd is divided at any given place. To illustrate suppose the owner is to cull this herd so that only cows which produced 5.25 per cent of butter-fat in their first lactation will remain in it, what per cent of butter-fat could he expect the remainder of the herd to produce? The answer is found in the last column of the table on the line with the 5.25-5.35 butter-fat percentage of the first column, to be 5.49 per cent. Should it have been desirable to know the butter-fat percentage of the culled section of the herd this is found in the sixth column to be 4.97 on the line with 5.15-5.25 of the first column. The number of individuals remaining in this herd after culling may be seen in the fourth and fifth columns. Since these are tabled for 1000 individuals they may be easily reduced to percentage should it be convenient to deal with the results in this way.

These results are of course only applicable to herds similar to the one being studied. The comparison of the butter-fat test make it seem likely that with only small error these results may be used for the whole of the Jersey breed and possibly the Guernsey breed.

BULLETIN 292

POTATO MOSAIC.[1]

DONALD FOLSOM.

SUMMARY

(1) Potato mosaic has been known in Europe for many years and in Maine since 1912. At present it is well established in this state. It is also well distributed over the United States.

(2) The mosaic of tobacco, a plant related to the potato, has been thoroughly studied and apparently is quite similar to potato mosaic. However, there are important differences between the two maladies.

(3) Potato mosaic has certain marked effects upon the appearance, physiology, and yield of potatoes.

(4) It is transmitted by the tubers of infected plants, whether or not these plants have had time to show the usual

[1]This bulletin is largely based upon investigations conducted as a cooperative project between the Office of Cotton, Truck and Forage Crop Disease Investigations of the Bureau of Plant Industry, U. S. Department of Agriculture, and the Department of Plant Pathology of the Maine Agricultural Experiment Station. Such results of this cooperative investigation as are included herewith have already been published in different form as follows: Schultz, E. S., Folsom, D., Hildebrandt, F. M., and Hawkins, L. A. Investigations on the mosaic disease of the Irish potato. Jour. Agr. Research 17:247-274. Pl. A-B (col.), 25-30. 1919. Schultz, E. S. and Folsom, D. Transmission of the mosaic of Irish potatoes. Jour. Agr. Research 19:315-337. Pl. 49-56. 1920. The articles just mentioned are not, however, available to the general reader, except in libraries. Moreover they are written more from the standpoint of the investigator. It is believed that the information contained in them and certain other general information relative to the nature and importance of potato mosaic should be given to the potato growers of Maine as a Station bulletin. Dr. Folsom's name as author of the present publication implies no assumption of credit for work done other than that he has been the Station representative actively engaged in the prosecution of the cooperative investigations on potato mosaic and thus is the logical person to put the results obtained into form for a Station bulletin. Chas. D. Woods, Director.

symptoms before death. This transmission is not modified by seed treatment.

(5) Its infectiousness has been proved by means of grafting and of inoculations with juice from diseased plants.

(6) Aphids, or plant lice, have been shown to be important agents for natural transmission of mosaic from one potato plant to another.

(7) Transmission has been attempted by means of flea beetles, Colorado potato beetles (or "potato bugs"), seed-cutting knives, soil, and contact of seed pieces, leaves, stems, and roots, but has not yet been demonstrated with any of these agents.

(8) The effects of the spread of potato mosaic to healthy plants apparently cannot be avoided by the selection of hills or tubers or by discarding parts of the seed tubers, unless plant lice are controlled.

(9) The relation between this spread and differences between localities, varieties, fertilizers, and spray methods are being studied but have not been fully determined.

(10) Such spread has been reduced by roguing seed plots, that is, by removing mosaic hills as fast as they appear, and absolutely prevented by thorough control of certain kinds of insects.

(11) Potato mosaic is difficult to control but it is now possible to recommend measures that promise to be helpful.

INTRODUCTION.

The disease of Irish potatoes known as mosaic has been known for a long time in Europe, according to Quanjer[2], although without the present name always being applied or the true nature of the disease well understood. It was found to be prevalent in the potato fields of Aroostook County, Maine, in 1912[3]. In 1917 and 1918 it was reported from twenty-one states[4], includ-

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[2]Quanjer, H. M. The mosaic disease of the Solanaceae, its relation to the phloem-necrosis, and its effect upon potato culture. Phytopath. 10:35-47. Figs. 1-14. 1920.

[3]Orton, W. A. Potato wilt, leaf-roll, and related diseases. U. S. Dept. Agr. Bul. 64. 48 p. 16 pl. 1914.

[4]U. S. Department of Agriculture. Bureau of Plant Industry. Plant Disease Survey. Plant Disease Bulletin, Vol. [1]-2:1917-1918.

ing all those in which potatoes are an important crop. During 1919 the writer in company with others made a careful estimate of the amount of mosaic in 40 Green Mountain fields in Aroostook County and the same number of Bliss Triumph fields including many which were supposed to be above the average in quality. In these fields the percentage of hills that were mosaic varied from one-half to 100 per cent, averaging 28 per cent for the Mountains and 46 per cent for the Bliss. It is apparent that a mosaic-free field of these two susceptible varieties was extremely rare. As will be shown later, there is every reason to expect that the prevalence of the disease will increase unless effective measures are taken to check it.

Observations upon potato mosaic have been carried on in this country since 1912. Active experimental work has been done in Maine and elsewhere since 1916. Tobacco, a species in the same family of plants as the potato, also has a mosaic disease which has been studied for a number of years and is now comparatively well understood. In spite of all this, progress upon potato mosaic has been slow and it has been only recently that the evidence has justified the formation of definite conclusions regarding it. This delay has been largely due to certain differences of characteristics between tobacco mosaic and potato mosaic[5]. The mosaic of tobacco is far more easily transmitted from plant to plant than that of potatoes. The natural spread of tobacco mosaic is much more apparent than the natural spread of potato mosaic, since the former occurs early in the season while the latter occurs late, or at least the only known agent of potato mosaic transmission in Maine appears in large numbers too late in the short growing season for the newly infected plants to show the disease. Tobacco mosaic is not transmitted from one generation to another through the seeds, but potato mosaic is transmitted by the tubers, so that the full extent and nature of the spread of the latter in the field during any season can be

[5]A more detailed knowledge of these differences can be secured by comparing the two cited papers upon which most of this bulletin is based, with the following.

Allard, H. A. Further studies of the mosaic disease of tobacco. Jour. Agr. Research 10:615-632. Pl. 63. 1917.

Chapman, G. H. Mosaic disease of tobacco. Mass. Agri. Exper. Sta. Bul. 175:73-117. 5 pl. 1917.

ascertained only by growing and examining the progeny of the tubers. While these differences have in the past been puzzling to those who tried to demonstrate similarity between the mosaic of tobacco and that of potato, it now seems that the two are essentially similar maladies and that the principles discovered regarding the former may be safely assumed in general to govern the latter where they have not already been proved to do so, as described in this bulletin. This similarity should now facilitate progress in the study of potato mosaic.

APPEARANCE OF THE DISEASED PLANTS.

The leaves of mosaic potato plants are mottled with light green or yellowish green spots which vary greatly in abundance, location, and shape. They may be merely scattered sparingly, occurring on any part of the leaf, or may be numerous over the whole leaf. They often include or join parts of the larger veins or ribs, but may not come in contact with them. They may appear as dots or circles, but usually are irregular and often are elongate. They may be distinctly set off from the healthy green parts or may fade out gradually. They seldom are more than a quarter of an inch across, altho they may follow a vein for a longer distance. Usually the foliage is wrinkled or ruffled. In fact, this wrinkling ordinarily will be apparent to an observer before the mottling or spotting is, especially if the sunlight is allowed to strike the plants that are being looked at. Diseased plants are frequently dwarfed. Figures 28-30 show diseased leaves and plants.

The preceding description is most characteristic of the disease on the Green Mountain and Bliss Triumph varieties. In some cases with these varieties, and nearly always with Irish Cobblers, the spotting is absent and only extreme dwarfing and wrinkling indicate the presence of the disease. The Rural types seem to display the disease only as dwarfing and leaf wrinkling and curling, if at all. Some other varieties, as indicated later, are as yet not known to have mosaic even when they have been exposed to infection.

The dwarfing and the wrinkling and downward curling of the leaves that may be characteristic of mosaic plants should not lead to confusion with leaf roll, which is characterized by an

Fig. 28. Mosaic potato leaf.

Fig. 29. Mosaic dwarf and healthy Green Mountain hills.

Fig. 30. Mosaic and healthy potato plants produced by tubers from the same lot.

upward rolling of the leaves with dwarfing and a paleness or yellowing not localized in scattered spots. Moreover, this malady, together with certain other inheritable abnormalities of the leaves that may be phases of mosaic, probably requires the same practical treatment as does mosaic.

In a field with many mosaic plants the color of the mass of plants is lighter green, the rows are more ragged, the plants are not so robust or tall, and in case of dry weather yellowing and dying occurs earlier than with healthy stock of the same variety. See Figs. 29 and 30.

OTHER EFFECTS OF THE DISEASE.

A limited number of chemical tests[6] have indicated that mosaic is accompanied by an increase in the amount of sugars in the leaves and by a decrease in the amount of starch. Similar tests may eventually disclose the same differences in the tubers, but at present no way is known for distinguishing healthy dormant tubers from those which are transmitting the disease. The latter germinate as well as the former do. The blossoming stage is reached as soon by diseased plants as by healthy. Vegetative reproduction is modified so that the disease decreases the yield of tubers.

A number of tests have been made by various writers[7] comparing groups of diseased hills with groups of healthy ones regarding the yield of potatoes. These show that the disease in such conditions reduces the yield. They thus agree with the results of similar studies made in Maine, wherein larger numbers of hills were used.

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[6]Schultz, E. S., Folsom, D., Hildebrandt, F. M., and Hawkins, L. A. Op. cit.

[7]Anonymous. Mosaic disease as a factor influencing yield. Potato Magazine 2^5:11, 27. 1919.

Barrus, M. F. Potato-mosaic and certified seed. Potato Magazine 1^4:13-14. 1918.

Murphy, P. A. The mosaic disease of potatoes. Agric. Gaz. Canada 4:345-349. Illus. 1917.

Orton, W. A. Op. cit.

Parker, R. C. Testing seed potatoes on Long Island. Potato Magazine 2^3:8, 22-23; 2^4:19, 27-28. 1919.

Wortley, E. J. The transmission of potato mosaic through the tuber. Science n. s. 42:460-461. 1915.

For such comparison plots of about one-fifth acre each were grown in Aroostook County in 1918. Two plots were planted with seed that came respectively from healthy and mosaic hills of a plot which was planted in 1917 with a good commercial strain of Green Mountains. The former, with 11 per cent of the hills removed during the season because of their showing mosaic symptoms, yielded at the rate of 89 barrels an acre while the latter yielded at the rate of 69 barrels an acre, with no hills removed[8]. A similar pair of plots of a commercial strain of Bliss Triumphs showed yield rates of 75 barrels, for the comparatively healthy plot with 15 per cent of the hills removed, and 53 barrels, for the all-mosaic plot with no hills removed. The differences might have been greater if the plants on the plots had not been frozen down in the latter part of June.

The preceding comparisons refer to healthy and entirely diseased lots and so may seem to be somewhat inapplicable to conditions where a large number of the plants are not diseased and where these may possibly be able to make up for the deficiency of affected plants by making better growth at their expense. However, in 1918 a nearly healthy Green Mountain fifth-acre plot, with 13 per cent of the hills removed, yielded at the rate of 84 barrels an acre, while another plot from the same strain, with 45 per cent of the hills mosaic but with no hills removed, yielded only a half-barrel more per acre. Furthermore, the effect of mosaic upon yield is important because of the natural increase of the disease. In the absence of any control measures it has been found that often a healthy lot of a susceptible variety will show symptoms of the disease in some hills the next year after being grown near to diseased stock and will

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[8]The removal of hills from the healthy plot probably was largely a loss. It has been determined (Stewart, F. C. Missing hills in potato fields: their effect upon the yield. N. Y. (Geneva) Agri. Exper. Sta. Bul. 459: 45-69. Fig. 3. 1919.) that on the average the adjoining hills make up in increased yield 46.4 per cent of the loss resulting from a missing hill when such missing hills are due to failures to germinate. It is not believed, however, that this rule is applicable to the plots under discussion since the diseased plants were not removed until the growing season was nearly half over and so previous to that time they were taking their share of space, water and food materials which would have been used for the benefit of the adjoining hills if these diseased hills had been represented by misses from the start.

thereafter from year to year have a larger percentage of hills affected, thus approaching the all-mosaic condition with which the most of the yield comparisons are concerned.

TRANSMISSION BY THE TUBERS.

Three questions are involved with tuber transmission—whether diseased stock recovers to any extent, whether such stock becomes worse from season to season, and whether tubers from apparently healthy plants may transmit mosaic through the dormant season.

It appears that when a plant once becomes diseased, there is no recovery by it or by any of its progeny. In 1917 over a hundred mosaic hills were selected. Progeny of theirs, several hundred hills, were grown in 1918 and showed mosaic in all cases. All healthy plants were removed from two one-fifth-acre plots grown in 1917, and in 1918 these two lots, grown again on fifth-acre plots, contained no healthy plants. A number of small lots all-mosaic in 1917 were again entirely diseased in 1918.

These results were duplicated with stocks grown in 1918 and tested in 1919. Over 150 hills were selected, furnishing 1100 hills of progeny, all mosaic. Stocks used previously in the two larger plots and in smaller lots were continued in use but remained diseased.

It is commonly considered that mosaic increases in severity from year to year and certain field observations seem to confirm this idea. In these cases, however, there was a tendency for the disease to change very little in severity as a result of transmission through the tubers from one season to the next. For example, stock selected as showing a medium stage of mosaic might show a slight stage in some hills and a bad stage in others the next season, but the average would be medium. The same was true of stock selected as showing a slight stage or a bad stage.

In this connection it should be pointed out that treatment of seed tubers with formaldehyde, corrosive sublimate, and heat have not appreciably affected the percentage of mosaic[9]. This is not surprising in view of the evidence, presented in this bul-

[9]Orton, W. A. Op. cit.

letin, that the disease is caused by something in the juice of the tuber or plant and not, as in many potato diseases, by an organism upon or in the surface layers of the tubers.

Tubers from apparently healthy plants often have produced mosaic plants. In fact, many groups of healthy plants have been selected but in any such lot of stock the disease has always appeared the next season unless the selected healthy group had been grown under certain conditions, to be described later in this bulletin. The frequency of the appearance of the disease in stock selected as being healthy was at first puzzling and led to tests of the communicability of the disease.

PROOFS OF INFECTIOUSNESS.

GRAFTS.

In order to disclose whether the disease could be transmitted from one plant to another, tests were made with methods that seemed most likely to succeed if such transmission were possible. Grafts were made with plants in the greenhouse, in the field both in the open and under cages, and with tubers in the field.

In preliminary trials in the greenhouse two methods were used, the cleft-graft and the inarch. Both gave cases of transmission, the originally healthy scion becoming mosaic after being grafted upon a diseased stock while its parent remained healthy. The former method proved to be more practical for securing successful grafts. By it the base of the scion was sliced down to a thin wedge, inserted between the parts of the split stock, and held in place with the help of adhesive tape.

The cleft-graft method was used somewhat more extensively in the field the following season, 1917, with 62 per cent of the originally healthy scions becoming diseased. In this test the parents of the scions were not observed.

In 1918 the same method was used again. In only thirty-three grafts of healthy scions on diseased stocks was satisfactory growth obtained and in each of these the scion became mottled while the parent plant remained healthy. In the case of five grafts of diseased scions on healthy stocks, these previously healthy stocks showed mosaic in their later growth. Eleven

controls, each consisting of healthy scion and stock, remained healthy, showing that the operation of grafting was not the cause of mottling.

Since aphids, or plant lice, were very abundant in 1918 and had not been controlled in previous grafting experiments, final tests were made both in the field and in the greenhouse with these insects eliminated[10]. In the greenhouse any vigorous new growth that was made by a healthy part of the graft became mosaic unless both stock and scion were healthy. In the field under cloth insect cages, healthy stocks produced mosaic shoots in spite of the fact that the mosaic scions soon died because of shading. That this was due to the grafting is indicated by the absence of mosaic in the stock at the time of grafting or at any time in ungrafted check stalks in the same hills.

In the preceding experiments either the Bliss Triumph or the Green Mountain variety was used. One test with Irish Cobblers—very resistant to mosaic—was made in 1919 with mosaic scions upon uncaged stocks. The result was that mosaic appeared in the new branches from the grafted stalks while ungrafted stalks remained healthy.

Tuber grafting was attempted in the following manner. A supposedly mosaic tuber and a likewise supposedly healthy tuber were split lengthwise into halves. The freshly cut surfaces of one-half of each were immediately brought into contact and the two halves securely bound together and planted in this condition. The remaining halves of the healthy and diseased tubers were planted separately as checks. In 14 such cases the separately planted or check halves produced diseased and healthy plants in accordance with the supposed condition of the original tubers. Likewise all of the diseased tuber halves in the attempted grafts produced mosaic plants. On the other hand only 11 of the healthy tuber halves in the attempted grafts produced healthy plants while 3 produced mosaic plants. Examination showed that in the case of the 3 last mentioned actual union had been established between the cut surfaces of the healthy and diseased tuber halves. No such union had occurred in the 11 cases where no transmission of the disease occurred.

[10]This precaution had been made necessary by the results of certain insect experiments which will be described later.

It is clear that these results, secured under different conditions and at various times and places, all indicate that such contact of plant tissue as is possible in a graft enables the causative agent of potato mosaic to pass from a diseased plant, or plant part, to one that is healthy, resulting in the latter becoming affected also.

JUICE INOCULATIONS.

While tests of communicability were being carried on by means of grafts, similar tests with the transference of plant juice were also performed. Both tubers and plants were used. Experiments were made in the greenhouse and field, and three varieties of potatoes were employed.

The juice from the crushed leaves and stems of diseased plants was introduced into a cavity in a half of a split tuber. Sometimes both the treated half and the untreated half, the latter planted as a control, produced mosaic plants. Often both produced healthy plants. Occasionally only one produced a diseased plant and always it was the treated half. Hence it appeared possible to transmit mosaic by inoculating seed tubers with the juice of affected plants.

Several methods were used in 1918 for introducing juice from crushed plants and tubers into the stems and leaves of healthy plants. While no treated plants developed mottling during that season, progeny of some of the groups of plants showed a high percentage of disease the following summer. During the latter season the progeny of check plants, treated the same as the inoculated plants but with water used in place of the juice of a diseased plant, were mosaic in 24 per cent of the hills, probably because of natural transmission in the field in 1918. Progeny of plants whose stems were split and partly immersed for several days in the juice obtained by crushing tubers from mosaic plants, were all mosaic. Of the progeny of plants which in 1918 were inoculated by means of capillary glass tubes inserted into the leaf stalks or petioles immediately after these tubes were taken, filled with juice, from a similar position in diseased plants, 77 per cent were mosaic. Other methods consisting of the application of juice, by means of a brush, upon rubbed, bruised, or slashed leaves, did not prove so effective.

New methods were used in the greenhouse with better results. Juice from crushed mosaic plants was applied to the young leaves of a healthy plant, growing from half of a split tuber, and rubbed in by crushing the leaves somewhat with the fingers. This application was made several times in the course of a month, beginning when the plants were from 2 to 6 inches in height. The plants thus treated usually became mosaic if new growths were produced. The same results were secured at the same time by rubbing and crushing together the leaves of mosaic and healthy plants. All new growth was healthy which was produced by the untreated plants from the check halves of the seed tubers or by control plants treated with juice from healthy plants. All these greenhouse plants were free from plant lice.

The former of these methods was used in the field in 1919, the Irish Cobbler variety being added to those used previously, namely, Bliss Triumph and Green Mountain. Some of the non-inoculated plants became mosaic early, due to infection in 1918[11], and an equal number of the inoculated ones also, from the same tubers. This was true also for some plants treated with the juice of healthy plants. Of the other plants in the experiment, all remained healthy except those inoculated with juice from mosaic plants. Of 48 such plants, 47 became mottled—doing so before aphids became numerous—in a series wherein juice was transferred between plants of the same variety. Forty-three of 47 such plants became mottled in another series wherein juice was transferred either from Bliss Triumph to Green Mountain, from Green Mountain to Bliss Triumph, from Green Mountain to Irish Cobbler, from Irish Cobbler to Green Mountain, or from Irish Cobbler to Bliss Triumph. The plants that were mosaic from 1918 infection did not show mottling until after the inoculations had been begun, so that, in spite of the customary precautions, a chance was offered for accidental transmission whenever healthy juice was applied to a series of plants that included some of these mosaic plants. This did not occur, thus showing that rubbing and bruising the leaves of a healthy plant subsequent to such treatment of a diseased plant was not sufficient

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[11]This assumption seems reasonable as a result of various experiments, with plant lice, described later.

for transmission. The absence of symptoms previous to that time was not the reason inasmuch as the virulent juice used for successful inoculations sometimes came from diseased stock that had not yet shown mottling.

Variations of the preceding experimentation were made in other series of inoculations in 1919. Inoculations were made in Green Mountain plants protected by insect cages, with similar results. In the cages, and also in the open both within and between varieties, single inoculations were made for comparison with the usual method of repeating the inoculation several times, with the same results even when made as late as July 20. In four series the juice for inoculation was transferred from plants in the worst stage of the disease, both within each variety and from Mountains to Cobblers, with the resultant appearance of the same sort of symptoms whereas the induced mosaic was often but not always of the worst type in the other inoculations.

Artificial transmission of potato mosaic by means of grafting and juice inoculation thus demonstrated the infectious nature of the disease and made necessary the discovery of a natural means of transmission. This was found to be a certain type of insects, as will be explained in the next section.

INSECTS AS CARRIERS.

EFFECT OF USING INSECT CAGES IN THE FIELD.

Simultaneously with the first experiments with grafts and juice inoculations, preliminary tests were made regarding transmission by insects. Potato plants were grown throughout the season of 1917 under cheesecloth cages. These cages were not entirely insect-proof but their use resulted in a reduction of mosaic that season. Only 5 per cent of the tubers from the healthy caged plants produced mosaic progeny the next season, while other healthy plants, grown outside the cages, produced progeny the following year with much greater percentages of mosaic.

Again in 1918 healthy plants were grown under cages. On account of the poor quality of the cheesecloth obtainable and the abundance of aphids in the field, many of these insects were found on some of the caged plants. However, all the tubers

from the caged hills were found in 1919 to be healthy, while uncaged stock of the same kind, grown near by, was mosaic in 1919 in 35 per cent of the hills for Bliss Triumphs and in 49 per cent for Green Mountains.

These results, wherein the normal spread of mosaic in the field was greatly reduced or eliminated by protecting healthy plants with insect cages, merely support other evidence that insects transmit the disease. Such evidence has required the transfer of insects from mosaic to healthy plants, with check plants both untreated and treated with insects from healthy plants.

PLANT LICE IN THE GREENHOUSE.

Since greenhouse conditions are more favorable to the control of insects, and since Allard[12] had demonstrated the transmission of tobacco mosaic by aphids, experiments with one species of these insects—the pink and green potato aphid, *Macrosiphum solanifolii* Ashmead—were begun in the greenhouse in the winter of 1917-18. Bliss Triumph plants were grown, of which about a fifth appeared mosaic when a few inches tall, as the result of field infection during the preceding summer. Aphids were permitted to disperse from these affected plants and also artificial transfers were made. Within a few weeks half of the plants were mosaic, the additional ones only in the youngest leaves instead of in all the leaves as when following tuber transmission. Moreover, all the progeny of these plants, even of those apparently healthy, were mosaic when grown in the winter of 1918-19. This and other cases of aphid transmission without the appearance of mosaic until the second generation is grown, affords the best explanation for the frequent appearance of mosaic early in the growth of the progeny of plants selected as healthy in a field containing aphids and mosaic plants. The same stock grown in part in the greenhouse in 1917-18 was used for field planting in 1918 when less than a fifth of the hills were mosaic.

A similar experiment with the same variety was performed in the greenhouse in 1918-19. Part of a lot of tubers was kept free from aphids by fumigation and only 11 per cent of the

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[12]Allard, H. A. Op. cit.

plants showed mosaic symptoms, from field infection. Another part of the same lot was grown near to a group of mosaic plants, of the same variety, which were heavily infested with aphids. Of this portion of the lot, 17 per cent were mottled from the beginning, from field infection. In addition 50 per cent of the group developed mosaic symptoms following dispersal of the aphids from the mosaic group, the plants next to the mosaic group all doing so.

A lot of 30 Green Mountain tubers in storage produced sprouts which became lightly infested with spinach or common green peach aphids (*Myzus persicae* Sulz.) from a neighboring heavily infested lot of sprouted tubers that had come from a purely mosaic stock and that later produced mosaic plants. Of these 30 tubers, 17 per cent produced plants that were mottled early, from field infection, while in addition 20 per cent showed mottling later, usually in shoots from eyes of the bud end and therefore probably the ones first to become exposed to aphid attack. A much larger part of the same general stock planted in the field was less than 20 per cent mosaic.

Green Mountain plants also were grown under insect cages in the greenhouse during the winter of 1918-19. In one experiment five tubers were split. A half of each produced a check plant which was uncaged and untreated and remained healthy. Of the other five plants, all were caged, two being treated with aphids from healthy potato plants and three with aphids from mosaic potato plants. The transfers of aphids were made at three different times and were followed finally by tobacco fumigation to kill the insects in order to save the plants for later observations. The former two plants remained healthy but the three others became diseased.

In another experiment with the same variety, 12 tubers produced 53 plants which showed no evidence of mosaic when small. Twenty-one of these healthy plants, selected so as to represent each of the original 12 tubers, were kept as untreated controls and remained healthy. About half of these were caged until almost full-grown. Eighteen others likewise representing each of the tubers were fed upon by aphids from mosaic potato plants. The insects were introduced upon diseased leaves which were laid upon the caged healthy plant when it was young, from 3 to 13 inches tall. The aphids were on the average about

130 in number when transferred and were allowed to remain for a week before being killed by tobacco fumigation. The mottling appeared after an average interval of 26 days, upon only the top-most leaves of any shoot. Thirteen or 72 per cent of the 18 plants became mosaic, due to transmission by the aphids. Many precautions were taken to eliminate the possibility of accidental infection, the soil being steam-sterilized, the seed-cutting knife flamed, contact avoided, white flies (*Aleyrodes vaporariorum* Westw.) and any species of aphids other than the one in use entirely eliminated, and conditions kept similar for controls and inoculated plants regarding light, temperature, humidity, location of seed piece in the tuber, soil fertilization and watering. Moreover, with controls other than the untreated ones, aphid-free mosaic leaves were laid upon the plants when young, or aphids from healthy potato foliage and from radish plants were introduced, all without any effect respecting mosaic.

Since potato mosaic may be acquired by one generation without the symptoms being shown until the tubers produce the second generation of plants, the preceding groups of plants were dug and the tubers planted in the field in 1919. The tubers from mosaic shoots produced diseased plants. Even those from apparently healthy shoots fed upon by aphids from diseased plants also produced mosaic plants. Those from the 35 other healthy plants produced healthy plants except the ones from two plants. Upon these two a few aphids were found which were of unknown origin, possibly from diseased plants.

In a third experiment, 9 Green Mountain tubers produced healthy plants, six seed pieces being cut from each tuber. The six plants from each tuber were put into as many separate groups having different treatments with results as follows. Two groups of untreated plants, one caged and the other uncaged, remained healthy. In the third group, caged, wingless spinach aphids were introduced on leaves which were impaled upon a stick thrust into the soil so that the aphids, about 170 in number, had to traverse the stick and soil to reach each caged plant, and 89 per cent became mosaic. In the fourth group, caged, the aphids, about 130 in number, were introduced to each plant on a piece of gauze, and 22 per cent became mosaic. In the fifth group, caged, 20 winged aphids were introduced into each cage in a small bottle and 11 per cent became mosaic. In the

last group, uncaged, each plant was kept in contact with a mosaic plant grown in a separate pot and one became mosaic following the detection of the presence of escaped aphids.

A final experiment yielded the best results because disease-free stock was used and the plants were grown during the spring and summer, thus being exposed to such conditions of light and heat as to enable them to maintain active growth for a longer period than the plants grown previously. Ten tubers were each split into four parts; two parts produced plants which were left uncaged and untreated, as checks, and two produced plants that were caged until after aphids had been introduced, allowed to feed, and killed by fumigation. The aphids, of the spinach kind, were taken from mosaic plants, about 150 in each case. To fifteen plants they were introduced by the leaf-on-stick method, described above, and all these fifteen plants became mottled within a few weeks. To five plants they were introduced, when on the terminal vegetative buds of mosaic shoots, within an open bottle laid upon the soil. This was an unfortunate method since many of the aphids soon became injured or killed by coming into contact with moisture collecting on the inside of the bottle, so that only one of the five plants became mottled. The 20 check plants remained healthy except one which became slightly mottled—the last one to do so—after uncontrolled aphids had been found on it several times.

The greenhouse experiments that have been described showed that both spinach aphids and potato aphids—two species of plant lice commonly found upon potato plants in Maine[13]—can transmit potato mosaic from diseased to healthy plants, and that this transmission sometimes may not be followed by the development of mosaic symptoms until the tubers produce the second generation of plants. Since plant lice in northern Maine become noticeable or numerous only during the latter part of the season, it is made clear how mosaic may commonly be spread in the field without the effects being apparent until the next season.

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[13]Patch, Edith M. The potato plant louse. Me. Agric. Exper. Sta. Bul. 147:235-257. Figs. 25-33. 1907.

Patch, Edith M. Pink and green aphid of potato. Me. Agric. Exper. Sta. Bul. 242:205-223. Figs. 47-49. 1915.

Also oral information has been received from the same authority concerning spinach aphids.

PLANT LICE IN THE FIELD.

The positive results of the greenhouse experiments were confirmed in the field in 1919. Eight Green Mountain tubers from a mosaic-free stock were each divided into three parts, a tuber furnishing the plants for each cage. In four cages the plants were fed upon by spinach aphids which were introduced from radish plants and they all remained healthy. In the other four cages the plants were fed upon by aphids introduced from mosaic potato plants and mosaic symptoms appeared in three of the cages before the plants were harvested. Nine similar tubers were split, a half from each being planted in the open where it produced a healthy plant. The other halves were planted in three cages into which spinach aphids from mosaic potatoes were introduced. Three of these nine plants became mosaic. The smaller percentage of infected plants in these field-cage experiments, as compared with those in some of the greenhouse experiments, is probably due to the much greater size of the plants in relation to each hundred aphids used, the 1919 season being very unfavorable to the development of aphids and favorable to the rapid, early growth of potato plants.

The various proofs of aphid transmission furnish the best explanation for certain field observations that have been made. In 1918 aphids were unusually numerous in northern Maine, much more so than in 1917. If they are an important cause of the spreading of mosaic, such spread should be greater in 1918, other conditions being equal, than in 1917. In fact it was greater, judging from certain stocks, grown in fifth-acre plots, that had all mosaic plants rogued out both in 1917 and 1918. These showed mosaic in 1918 in from 11 to 16 per cent of the hills as the result of infection from near-by diseased plots in 1917, while they showed mosaic in 1919 in from 20 to 30 per cent of the hills as the result of such infection in 1918. This difference is made more striking by the fact that these stocks were grown each next to all-mosaic plots in 1917, but in 1918 were grown each next mosaic-free or half-mosaic stock. In 1918 one rogued stock was grown next a half-mosaic stock while two rogued stocks were grown nine and eighteen rows away, respectively. The former showed mosaic in 30 per cent of the hills in 1919 and each of the latter in only 20 per cent. It is thus seen that

crease in the seasonal abundance of aphids and by greater proximity to diseased stocks, and therefore by conditions that seem the spread of mosaic was increased apparently both by an into favor aphid dispersal from diseased to healthy plots.

During 1918, the season of great abundance of aphids, three lots of tubers were harvested at progressively later dates during the increase in numbers of the plant lice. From each of 78 healthy hills—mostly Green Mountain—growing near to mosaic hills, one tuber was removed on August 15 and another on August 26, the remainder being harvested on September 12. Meanwhile aphids, which became noticeable on potato plants the latter half of July, had become very numerous about the middle of August and were more excessively abundant as the end of the month was approached, seeming when migrating to be as abundant as the flakes in an ordinary snowstorm. The three sets of tubers in 1919 produced plants mosaic in 6, 14, and 50 per cent respectively. Apparently some of the transmission occurred before August 15 but most of it took place after August 26. Such late infection of the tubers is apparently due to the late development of the chief cause of the spread of mosaic, namely, abundant dispersing aphids.

FLEA BEETLES.

Five caged groups of healthy Green Mountain hills were fed upon by flea beetles *(Epitrix cucumeris* Harris)[14] for a week, several hundred from all-mosaic potato plants being introduced into each cage. As controls, four similar groups were treated likewise except that the beetles were taken from plots of mostly healthy potatoes or from bushes. All the plants in this experiment remained healthy until harvested. This result at least indicates that flea beetles are not important in spreading potato mosaic, since the artificial infestation was much more severe than any ordinary natural one while the contemporary artificial infestations with aphids, described as causing mosaic transmission, were not as heavy as natural ones.

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[14]This insect is the subject of Bulletin 211 of the Maine Agricultural Experiment Station.

COLORADO POTATO BEETLES.

A similar test was made with larvae of Colorado potato beetles *(Leptinotarsa decemlineata* Say.), commonly called potato bugs. A hundred or more actively growing individuals were transferred from mosaic plants immediately to each of 10 healthy plants where they did more damage than is usually permitted by potato growers. However, the plants remained free from mosaic until dug. Checks, consisting of 5 untreated plants in the same cages as the 10 treated ones and of 9 plants grown in 3 other cages and fed similarly with beetles from nearly mosaic-free potato plots, also remained healthy.

OTHER INSECTS.

It is quite probable that sucking insects other than aphids contribute to the spread of mosaic. Such insects, including leaf hoppers and plant bugs, feed upon potato plants. A beet disease apparently somewhat similar to potato mosaic is transmitted by beet leaf hoppers *(Eutettix tenella* Baker)[15]. Aphids often appear to be more abundant than other types of sucking insects, but are smaller individuals than some types and may be less prevalent in some places and seasons. However, all seem to require similar control measures, regarding mosaic or otherwise, although much study could be done profitably upon the relations between mosaic and the various potato insects.

OTHER POSSIBLE FACTORS IN THE SPREAD OF MOSAIC.

THE SEED-CUTTING KNIFE.

The same knife was used, in 1919, to cut a mixture of mosaic and healthy stocks of tubers, to test whether the knife would carry enough juice from a diseased tuber to a healthy one to transmit the disease. First a tuber from an all-mosaic stock was cut, then one from a rogued stock, and so on. Each

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[15]Ball, E. D. The beet leafhopper and the curly-leaf disease that it transmits. Utah Agri. Exper. Sta. Bul. 155. 56 p. 5 figs. 5 pl. 1917.

Shaw, H. B. The curly-top of beets U. S. Dept Agri. Bur. Plant Indus. Bul. 181. 46 p. 9 figs. 9 pl. 1910.

tuber—200 in all—was cut into four pieces, those from all-mosaic stock being sliced across and those from the rogued stock being quartered. The cut seed was further mixed in a sack and left for over a day. Then the seed pieces from the all-mosaic stock, having been cut in a different shape from those of the other stock, were sorted out and discarded. The row of 400 plants grown from the rest contained 72 mosaic plants. These evidently were diseased because of infection in 1918, since another check row of 400 plants, from 100 tubers of the same barrel, contained 85 mosaic hills although no chance had been given since harvesting in 1918 to get the disease.

A similar test, but involving contact of vines in the row also, was made with the same stocks. Instead of removing the seed pieces of the all-mosaic stock, all the seed pieces were planted unsorted in two rows. Of the 800 plants 475 were mosaic, 400 of course coming from the all-mosaic stock. Since the additional 75 is less than the 85 in the check row, no transmission since the harvesting of 1918 was evident, except of course that through diseased tubers.

In 1918 a number of tuber units, each a group of hills from one tuber, were partly mosaic. It was thought that such partial infection of tuber units might be due to knife transmission. Consequently in 1919, when most of the tuber units were planted, usually three knives were used in rotation, each one being immersed in a sterilizing solution, 4-per cent formaldehyde, when not in use. However, the partial infection of tuber units was as common as in 1918 and as in the case of the tuber units planted in 1919 without knife sterilization.

These various tests indicate that the seed-cutting knife is negligible as a factor of mosaic transmission.

CONTACT.

The effect of contact between mosaic and healthy plants was first studied in the greenhouse. As has been described, of nine healthy plants each grown with stems and leaves in contact with those of a mosaic plant, one showed mottling but not until after a few uncontrolled aphids, possibly from mosaic plants, were discovered upon it. At about the same time 8 healthy plants from as many different Green Mountain tubers were

grown in the same pots with mosaic plants, roots as well as stems and leaves being intermingled. Opportunity for infection through the roots was increased by the transplanting of the healthy plant into the potful of soil containing the diseased plant, with more or less consequent breakage of roots. The 8 plants remained healthy, as did 16 others grown from the same tubers and by themselves. This result was in marked contrast with a contemporary experiment, already described, wherein a certain method of transferring plant lice resulted in 100 per cent infection.

In the field, 18 healthy Green Mountain plants were grown under cages together with mosaic plants. Six soon crowded out their diseased companions by shading them. All remained healthy except for the uppermost leaves of one stalk of one plant. These were mottled on August 27, had aphid skins and aphids clinging to them, and were near a small hole punched accidentally in the cloth.

In one of the tests with the seed-cutting knife, as described above, a mixing of mosaic stock in the rows with rogued stock did not result in any increase of mosaic over that seen in the same rogued stock unmixed.

In 1917 five Green Mountain hills were selected as being healthy and were harvested. In 1918 the hill lots from these five hills were found to be partly mosaic, often with several healthy hills between successive mosaic ones in the row. The healthy hills were harvested separately and classified according to the proximity to mosaic hills. Class 1 consisted of hills each between two mosaic hills, class 2 of hills each between a mosaic and a healthy hill, and classes 3, 4, 5, 6, and 7 respectively of hills each with 1, 2, 3, 4 and 5 healthy hills between it and the nearest diseased hill. The next season the tubers, 337 in all, were planted uncut. For class 1 the mosaic percentage was 54 per cent, for class 2, 63 per cent, and for the other 5 together, 40 per cent. For classes 3 to 7 the percentage was respectively 56, 24, 54, 24, and 17 per cent. Being next to a mosaic plant in the same row thus seemed to increase the chance of infection as much as 54 or 63 per cent is greater than 40 per cent. It probably is a contributing factor in mosaic transmission only or chiefly by aiding aphid transmission.

Similar evidence was secured by comparing two treatments of Green Mountain lots. Removal of both the mosaic hills and

all the healthy hills next to mosaic hills in the row did not cause any reduction of infection as compared with the removal of only the mosaic hills.

It seems from the facts so far secured that contact infection can not be very common or important, especially when considering the results obtained from artificial inoculations and with aphids. However, some infection by contact possibly may occur too late to be evident during the season in which it occurs. Experiments on this point are not completed but stocks are available for growing the second generation in 1920 to test this possibility. Of course any measures necessary to prevent contact would be included in those necessary to avoid aphid transmission, which obviously often is made easier by contact although apparently frequent without contact.

SOIL.

The causes of many potato diseases are carried both from place to place and from season to season by means of soil. It is maintained that 80 per cent of field infections of tobacco mosaic originate in contaminated soil[16]. Hence it has seemed necessary to disclose any soil harboring of potato mosaic that may occur.

In the greenhouse twelve Green Mountain tubers were split. Half of each was planted in steam-sterilized soil and the other half in soil from which a full-grown mosaic plant had been removed either a day or a fortnight previously. The 24 plants were all healthy, as was also the second generation of the same stock.

While soil transmission was favored in this greenhouse test by the shortness of time between the growth of succeeding crops in the same soil, there were lacking certain factors in the possible soil-harboring in fields, namely, old stalks, volunteer potato plants, and hibernating insects. Therefore three rows of Green Mountain rogued stock were planted in 1919 across the sites of a 1918 twenty-per cent mosaic plot and a wholly diseased one, both of Green Mountains. All mosaic hills were dug and the seed pieces examined to determine the volunteers. Disregarding

[16]Chapman, G. H. Op. cit. See p. 80.

the latter, 28 per cent of the hills upon each site showed mosaic, mostly early, from infection in 1918.

Similar negative results were given by a more extensive test wherein 19 rows of rogued stock were planted across the sites of fourteen of the 1918 plots. Practically all the mosaic which occurred was shown by July 30 and so was judged to be due to infection occurring in 1918. Mosaic hills were dug and, disregarding volunteers, formed 23 per cent of the total, 4,466. A record was kept for each of the 14 parts. Among these there were only four marked variations from the average. These consisted of a deviation upward and one downward for the sites of two half-mosaic plots and similar deviations for the sites of two comparatively mosaic-free plots.

It therefore appears that the cause of potato mosaic is not transmitted in soil, except in discarded or ungathered tubers. These, however, may constitute an important means for the harboring of mosaic from season to season in a piece of land, since they produce volunteer plants, which, if mosaic, furnish a number of well-distributed sources of infection through aphid transmission.

LOCALITY.

The symptoms of mosaic may vary according to the region. The same stock of mosaic potatoes has been divided, part being sent to Colorado and part kept in northern Maine. The usual mottling of mosaic stocks was seen in Maine but did not appear in Colorado. With part of a stock sent to Washington, D. C., some mottling was noted but there were a number of doubtful cases, while the part kept in Maine was distinctly mottled.

When a number of lots were divided and planted at the two farms of the Maine Agricultural Experiment Station, the part of a lot grown at Highmoor Farm in the southwestern portion of the state often showed much less mottling than the part grown at Aroostook Farm in the northeastern portion. In two out of three seasons the difference has been very marked and the reverse was never seen.

Such a difference is not due to recovery in one place but rather to an obscuring of the mottling, as indicated by the reappearance of distinct mottling in affected stock returned to north-

eastern Maine. Also, in the latter region hot weather sometimes has been observed as apparently causing mosaic plants to lose their mottling, which again was plain after the return of cool weather.

The effect of differences in locality upon the symptoms shown by plants already diseased of course has no real effect upon the spread of mosaic. Undoubtedly one condition alone—the abundance of aphids, if no other—may vary enough in different regions or localities to affect the spread of the disease. Such problems are yet to be worked out.

VARIETAL RESISTANCE AND IMMUNITY.

The Irish Cobbler variety is practically free from mosaic in northern Maine, in marked contrast to the Green Mountains and Bliss Triumphs. Other varieties resemble the Cobblers. The extent and possible causes of immunity and resistance among the varieties are being determined.

FERTILIZER VARIATION.

Variations in the constitution of commercial fertilizers and the addition of special substances to the soil have not had any great or important effect upon mosaic already acquired. How much they might influence the resistance of susceptible varieties to mosaic infection, is being studied.

SPRAY METHODS.

Direct effect of any kind of spray upon mosaic has not been evident and could hardly be expected in view of the difference between the location of the spray on the outside of the leaves and that of the infectious substance in the juice. However, certain spraying methods may help to affect the mosaic problem through the control of plant lice.

METHODS OF CONTROL.

HILL SELECTION.

For several years many groups of healthy hills, numbering many hundreds of plants altogether, have been selected in the

experimental plots in which diseased plants, too, were growing. With the exception of those protected from insects, as previously described, no such lot of potatoes was free from mosaic in the next generation after selection. When selected in 1918, the various lots in one 1919 series contained from 12 to 76 per cent of mosaic. Altogether there were about 4,000 hills of which 1,200, or 30 per cent, were mosaic. This is not surprising since the selected hills were grown near to mosaic hills and it is probable, judging from experiments discussed previously, that aphid transmission occurred too late in the season of 1918 for symptoms to appear and was followed by the usual tuber transmission.

The selection of healthy hills, then, does not result in a mosaic-free stock when aphids are uncontrolled. Further selection among 140 healthy hill lots—mostly Green Mountain and a few Bliss Triumph—was made on the basis of the number of tubers, whcih varied from 2 to 12 in a hill. A high percentage of mosaic, 86 and 60 per cent respectively, was shown by the progeny of hills with 2 or 3 tubers in a hill. Otherwise the mosaic percentage, varying from 30 to 53 per cent, showed no consistent relation to the number of tubers. It thus seems that possibly the increase of mosaic could be reduced somewhat by discarding hills with the lowest yields but it would not be avoided by this practice, and such hills are discarded because of the smallness of their yield whenever hill selection is practiced.

SELECTION OF TUBERS.

Frequently the tubers from a healthy hill vary in regard to mosaic, some being healthy and others diseased. To determine whether the selection of tubers according to size would have any effect upon mosaic percentage, each of the 140 hill lots which were considered in the preceding section was planted in the order of decreasing apparent size of the tubers. Later observations showed that half of them contained both healthy and diseased tubers, the latter tending to be more numerous as the relative size of the tubers was greater. The tendency, however, was not marked enough to make it seem desirable to select tubers according to weight or size. The same conclusions resulted from a similar study of 98 partly diseased hill lots of which the 2 to 6 largest tubers of each were planted.

In 1918, stock unrogued and partly mosaic in 1917 was divided into two parts, one unsorted and the other with tubers of 2 ounces and less in weight discarded. The percentage of mosaic differed only two-thirds of one per cent, being about 45 per cent for each. The plots observed covered about one-fifth acre each.

SELECTION OF SEED PIECES.

Tuber units, or groups of plants each from a single tuber, are often mixed regarding mosaic, that is, partly diseased and partly healthy. In experiments conducted in 1918 and 1919 with such tuber units, there was a preponderance of mosaic in bud-end hills. This, however, is of no value regarding the problem of control because of the small percentage of tubers that will produce both healthy and diseased plants. It is far more important to take measures which will eliminate all tubers that are either partly or wholly mosaic.

REMOVAL OF DISEASED PLANTS.

Since the selection of hills, tubers, or seed pieces seems, with our present knowledge, to be of no great value in securing or maintaining healthy potato stocks, contrary to experience with certain other potato diseases[17], the results secured by removing diseased hills from seed plots are of interest. This method includes several careful inspections for mosaic plants, their removal as soon as found, and of course harvesting and storing the crop separately from all diseased stock. If only one inspection is made it should not be made until all of the plants from diseased tubers have become large enough to show mosaic. In 1919 in all-mosaic stocks only 67 per cent were mottled in Green Mountains and 89 per cent in Bliss Triumphs by July 9. In the early part of that season the unusually high temperatures probably retarded the development of mottling directly and on the other hand hastened it indirectly by accelerating the development of the plants. All plants in these lots were plainly mosaic by the last of July. A single inspection made late enough to

[17]See Me. Agri. Exper. Sta. Miscel. Publ. 535, on "How to Control Potato Enemies."

get all the diseased plants may leave them in the field long enough to serve as centers of infection if aphids appear early and increase rapidly. Therefore two or more inspections are preferable, so that diseased plants may be removed or "rogued" soon after they show that they are diseased.

In 1917 three one-fifth-acre plots, each consisting of 6 rows next to an all-mosaic plot, had from 32 to 49 per cent of the hills mosaic. Two—a Green Mountain and a Bliss Triumph—were rogued three times and in 1918 the stocks were mosaic in 11 and 16 per cent of the hills respectively. The third lot, Green Mountain, was rogued once and in 1918 was mosaic in 13 per cent of the hills. Thus roguing in 1917 made a considerable reduction in the mosaic percentage in spite of the proximity to all-diseased plots—no plant being more than a few rows away—and of the abundance of mosaic hills in the lots. In 1918, the year of excessive abundance of aphids, these three lots of stock were planted together, one lot only being next to a half-mosaic plot, and of course they contained fewer mosaic hills. Roguing in that year was not so effective, since the mosaic percentage increased to from 20 to 30 per cent shown in 1919. This is undoubtedly due to aphid dispersal and indicates the need of isolating the seed plot.

ISOLATION OF SEED STOCK.

If healthy stock of a susceptible variety is grown near to mosaic stock it will acquire more or less of the disease. On the other hand, if it is grown so far from mosaic stock that no insects, especially aphids, will come to it except from weeds or healthy potatoes, it may be expected to remain healthy, judging from the evidence at hand. Tests of this method are under way. As far as is known, such an isolated seed plot, even if partly mosaic, may produce healthy potatoes if it is rogued completely of mosaic hills early enough.

Recommendations for the Control of Potato Mosaic.

Do not expect to control or reduce potato mosaic by means of sprays, seed treatment, or soil treatment, except by spraying methods which control plant lice. Use as healthy stock as can

be obtained. Plant at least part of it in a seed plot of sufficient size to furnish seed for the next year's planting. Select land for this purpose as remote from all other potato fields as possible and land which has not grown potatoes for one or more years. Give the seed plot special care. Rogue all mosaic plants from the seed plot as soon as they show the disease. In case aphids are unusually abundant, the spreading of mosaic by them possibly would be reduced by controlling them with suitable spraying methods, which are advised for the seed plot every year inasmuch as even a small and inconspicuous number of aphids may spread mosaic. Such spraying methods, according to recent publications upon this question[18], require adding ¾ pint of "Black Leaf 40" or of a similar nicotine preparation to each 50 gallons of bordeaux mixture. In localities where it is feasible to make a separate spray for aphids, the ¾ pint of nicotine solution is more effective if added to 50 gallons of water containing 2 pounds of laundry soap first dissolved in hot water. Moreover, if preferred, kerosene emulsion may be used instead of the nicotine spray. Regardless of whatever spray is used for plant lice, it is essential that it be applied in such a manner that it reaches the insects themselves, since the effectiveness of the spray depends upon contact. Hence it is necessary to have the nozzles arranged on the spray boom so as to cover the under sides of the leaves and the stalks of the plants, as well as the upper leaf surfaces, with the spray materials. Finally, avoid any chance of mixing the seed-plot stock with the rest by harvesting and storing it separately from the general stock. Repeat this each year.

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[18]Britton, W. E. Eighteenth report of the state entomologist of Connecticut for the year 1918. Connecticut Agri. Exper. Sta. Bul. 211:249-352. Figs. 7-13. Pl. 21-36. 1919.

Britton, W. E., and Zappe, M. P. Kerosene emulsion versus nicotine solution for combating the potato aphid. Jour. Econ. Entomology 12:71-81. 1919.

Houser, J. S., Guyton, T. L., and Lowry, P. R. The pink and green aphid of potato. Ohio Agri. Exper. Sta. Bul. 317. 21 figs. 1917.

Patch, Edith M. Spray pink and green potato aphids. Potato Magazine 1^{12}:8-9, 31. 1919.

Regan, W. S. Potato plant lice and their control. Massachusetts Agri. Exper. Sta. Bul. 177:135-146. 1917.

BULLETIN 293

STUDIES IN MILK SECRETION VIII.

On the Influence of Age on Milk Yield and Butter-Fat Percentage, as Determined from the 365 Day Records of Holstein-Friesian Cattle.*

By John W. Gowen.

SUMMARY

This paper presents a study of the relation of age to the milk yield and to the butter-fat percentage of Holstein-Friesian advanced registry cattle for the 365 day test.

Two thousand, five hundred and eighty-six records of complete year test are analyzed in this paper.

These records show that milk yield rises at an ever decreasing rate as the age of the cow increases until the age of maximum productivity is reached, from this age of maximum productivity the milk yield declines at an ever increasing rate as age increases.

The butter-fat percentage for these Holstein-Friesian cows declines slightly as the age of the cow advances. This decline on the average amounts to only 0.150 per cent. Considerable variation on either side of this mean rate of decline is shown by the records.

The advanced registries for the different associations of stock growers handling the pure breeds of dairy cattle have focused the attention of the milk producers on the well known fact that age plays a very considerable part in the milk yield of a cow during any given lactation. The advanced registry officials have realized the necessity of taking cognizance of this effect of age on milk yield in determining the requirements which must be met by a cow. At the time when these requirements

*Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 134.

for the advanced registries were drawn up little information was available as to what real changes were brought about in the cow's milk yield or butter-fat yield by the advancing age of the cow. In view of this lack of data the herd associations adopted an arbitrary standard. This standard called for the production by Holstein-Friesian cows of not less than 250.5 pounds of butter-fat for the 365 day period at two years old and for every day that she exceeds two years of age the requirement in butter-fat shall be increased one-tenth of a pound. This increased requirement of one-tenth of a pound of butter-fat daily for each day's increase in age shall continue till the requirement reaches 360 pounds at the age of five years after which no further increase shall be made. Such a standard is obviously a linear function, that is, the cow's possibilities of butter-fat production must commence at 250.5 pounds as a two year old and must go on increasing one-tenth of a pound each day, one uniform step up each day, until she is 5 years old when the cow is supposed to be at her maximum productivity.

One of the first investigations[1] undertaken as part of the animal husbandry investigations of the Maine Agricultural Experiment Station was a study of the relation of age to milk yield and butter-fat percentage. In these first studies it was shown that milk yield does not increase with age linearly as was assumed to be the case by the Registry Officials. The increase of milk yield with age was found to be a logarithmic function.

Since the time when this law was first determined the essential conclusion then drawn has been established for milk yields from a variety of dairy cattle under diverse conditions. The seven day milk yields of Jersey cows have been shown to have a logarithmic relation to age[2]. The milk yield of Ayrshire cows likewise follows the logarithmic law[3]. A pure bred herd

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[1]Pearl, Raymond. 1914. On the Law Relating milk flow to age in dairy cattle. Proc. Soc. Expt. Biol. and Med. Vol XII, pp. 18-19.

[2]Pearl, Raymond and Patterson, S. W. 1917. The Change of Milk Flow with age, as determined from seven day records of Jersey cattle. Annual Report of the Maine Agricultural Experiment Station for 1917. pp. 145-153.

[3]Pearl, Raymond and Miner, John Rice. 1919. Variation of Ayrshire Cows in the Quantity and Fat Content of their milk. Jour. Agric. Research, vol. XVII, No. 6, pp. 285-322.

of Jersey cows maintained under the condition of a good dairy farm follows the logarithmic law in their relation of milk yield to age[4]. The registry of merit Jerseys for their 365 day records have also been shown to change in their milk flow logarithmically with age[5].

The necessity for a knowledge of these logarithmic functions for the different breeds has been well illustrated by the work of this laboratory for without it no comparison of milk records made at different ages can legitimately be made either for the purpose of determining the value of different sires as shown by the milk yield of their daughters or for inheritance studies. Such studies have already been reported in part for the Jersey[6] and Guernsey[7] breeds and also for inheritance studies on crosses of dairy and beef breeds[8]. The purpose of this paper is to determine the relations of milk yield and butter-fat percentage to age for the 365 day records of another breed, the Holstein-Friesian. These studies have given us the knowledge necessary to determine the transmitting ability of Holstein-Friesian sires. These facts will be published in a later paper of this series.

The Holstein-Friesian association have collected in their advanced registry work a large number of 365 day records. These year records, volumes 18-28, have been used for a study of the constituents of the milk of Holstein-Friesian cows[9]. The

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[4]Gowen, John W. 1920. Studies in Milk Secretion. V. On the Variation and Correlation of Milk Secretion with Age. Genetics, vol. 5. 111-189.

[5]Pearl, Raymond, Gowen, John W. and Miner, John Rice. 1919. Studies in Milk Secretion VII. Transmitting Qualities of Jersey Sires for Milk Yield, Butter-fat Percentage and Butter-Fat. Annual report of the Maine Agricultural Experiment Station for 1919, pp. 89-204.

[6]Loc. cit.

[7]Gowen, John W. 1918. Report of Progress on Animal Husbandry Investigations in 1917. Annual Report of the Maine Agricultural Experiment Station for 1918, pp. 205-228.

1919. Report of Progress on Animal Husbandry Investigations in 1919. Annual Report of the Maine Agricultural Experiment Station for 1919. pp. 249-284.

[8]Gowen, John W. 1918. Studies in Inheritance of Certain Characters of Crosses between Dairy and Beef Breeds of Cattle. Jour. Agric. Research, vol. XV, No. 1, p. 1-57.

[9]Gowen, John W. 1919. Variations and Mode of Secretion of Milk Solids, Jour. Agric. Research, Vol. XVI, No. 3, p. 79-102.

present study includes besides these records those of volumes 28 and 29. One noticeable fact which appears in the study of these later records, is the advance in the mean age of the cows which are tested for 365 day records over that of the previous study.

These records are arranged alphabetically according to the names of the cows in the advanced registry. Such an arrangement gives no clue as to any relationship which may exist between the attributes age and yearly milk yield and age and yearly butter-fat percentage. The data have been rearranged in a correlation table to allow the determination of these relations.

Two thousand five hundred and eighty-six complete 365 day records of the milk yield and age, and butter-fat percentage and age were available for study.

These records range from an age of 1 year and 6 months—2 years to 15 years—15 years and 6 months. The milk productions range from 6000-7000 to 31000-32000 pounds for the year period. The butter-fat percentage ranges from 2.4-2.5 to 4.6-4.7 per cent. The size of the range obviously requires a grouping of the material into classes. These classes have been chosen as 6 months for age commencing at one year and 6 months. The class interval for milk yield was taken as 1000 pounds of milk commencing at 6000 pounds for the year. The class interval for the butter-fat percentage was chosen as 0.1 per cent.

The resulting correlation tables are shown in tables 1 and 3. Table 1 shows the association of milk yield with age and table 3 the association of butter-fat percentage with age.

The mean milk yield for this group of cows was 16233.6 pounds for the year period. The standard deviation or the amount which they varied was 4039.3 pounds and the coefficient of variation of the milk yield was 24.9. The mean age at which these cows were tested was 4.57 years. The standard deviation for the ages was 2.25 years and the coefficient of variation was 49.11. It will be noted that the milk yield is slightly higher than that published for the first group of these data[10] as taken from volumes 18-28 of the previous paper. The slight increase in milk yield no doubt comes from the slight increase in age of the cows tested in the later volumes.

[10]Loc. cit.

TABLE 1.

Correlation Surface for the Variables Age at Commencement of Test and Milk Yield in 365 Days.

HOLSTEIN-FRIESIAN CATTLE.

Age at Commencement of Test

Milk Yield	1:6–2:0	2:0	2:6	3:0	3:6	4:0	4:6	5:0	5:6	6:0	6:6	7:0	7:6	8:0	8:6	9:0	9:6	10:0	10:6	11:0	11:6	12:0	12:6	13:0	13:6	14:0	14:6	15:0–15:6	
5000–6000																													
6		1																											1
7	3	4	1																										8
8	6	9	3	1	1																								20
9	10	20	10	6	2	2																							50
10	6	39	24	9	10	6	1	2	1	2				1				1											102
11	11	67	38	13	16	8	8	5	2	2	2	2						1											175
12	13	62	28	10	24	14	10	10	6	2	3	1	5	2	1			1	2			1	1						196
13	7	79	42	35	21	18	19	14	11	7	5	6	4	1	4		1	1		1		1	1	1					279
14	6	45	31	26	24	20	22	19	16	8	8	3	6	3	5	4	2	6	1		1	1						1	258
15	4	44	39	18	23	12	22	16	9	11	14	10	7	5	5	6	5			1				1				1	253
16	3	37	26	20	28	22	19	25	19	13	8	8	4	8	3	4	1	4	2	2	1	2							259
17		30	26	16	21	22	18	29	13	20	7	10	1	6	6	4	3	2	3										237
18	1	18	11	20	18	13	14	22	17	16	8	8	1	8	6	1		1	2										185
19		8	7	10	14	12	9	10	14	14	12	8	4	5	6	6	1	2			1								143
20	1	4	7	4	9	6	13	7	7	10	14	4	5	2	6	6	1				1		1						108
21		3	1	7	5	6	9	6	8	5	2	8	5	5		1	3	1	2				1						78
22		5	2	3	5	6	4	2	10	9	4	5	5	4			3	2	1		1	1							72
23				2	5	2	4	4	4	6	5	2	2	3	3		1												43
24				3		3	4	2	2	2	4	3	1	4	2		2												32
25						1	2	2	5	3	2	2		1	1	2	2	1			1								25
26					1	1	1	2	2	2	3	2	4	1		1	1												21
27					1			5	1	3	1	2		3															16
28				1		1	1	2		1		1	1	1						2									11
29								1	1	1	1		2		1			1											8
30						1		1	1		1																		4
31												1			1														2
32000–33000																													
	71	475	296	204	228	176	180	186	149	137	104	86	57	63	50	35	26	24	13	6	6	6	4	2				2	2586

Observation of table 1 shows that there is a considerable relation of milk secretion to age. The correlation coefficient as deduced from these data is $+0.4332 \pm .0108$. The extreme skewness of the data tends to reduce the size of the correlation coefficient as compared to the true relationship which does exist. In view of this fact only slight dependence can be placed in its absolute value. However, since the true amount of relationship would be increased rather than decreased were the skewness removed, it follows that there is a distinctly significant association of milk secretion to age. As our object is not the amount of the correlation which exists between these variables age and milk yield but is the form and equation to the curve which describes the relation we need not pause longer on this phase of the subject.

Proceeding to the calculations of the mean milk production within the age groups as seen in table 1 we find the mean 365 day milk yields to be those shown in table 2.

TABLE 2.

Mean 365 Day Milk Yield of Holstein-Friesian Cows at Different Ages.

Age at Test	Mean milk Yield	Age at Test	Mean milk Yield
1 yr. 6 mo. to 1 yr. 11 mo.	12007	8 yr. 0 mo. to 8 yr. 5 mo.	19405
2 yr. 0 mo. to 2 yr. 5 mo.	13774	8 yr. 6 mo. to 8 yr. 11 mo.	18560
2 yr. 6 mo. to 2 yr. 11 mo.	14264	9 yr. 0 mo. to 9 yr. 5 mo.	18414
3 yr. 0 mo. to 3 yr. 5 mo.	15623	9 yr. 6 mo. to 9 yr. 11 mo.	19654
3 yr. 6 mo. to 3 yr. 11 mo.	15860	10 yr. 0 mo .to 10 yr. 5 mo.	17292
4 yr. 0 mo. to 4 yr. 5 mo.	16528	10 yr. 6 mo. to 10 yr. 11 mo.	17500
4 yr. 6 mo. to 4 yr. 11 mo.	16972	11 yr. 0 mo. to 11 yr. 5 mo.	19833
5 yr. 0 mo. to 5 yr. 5 mo.	17511	11 yr. 6 mo. to 11 yr. 11 mo.	19833
5 yr. 6 mo. to 5 yr. 11 mo.	18178	12 yr. 0 mo. to 12 yr. 5 mo.	16000
6 yr. 0 mo. to 6 yr. 5 mo.	18675	12 yr. 6 mo. to 12 yr. 11 mo.	17000
6 yr. 6 mo. to 6 yr. 11 mo.	18760	13 yr. 0 mo. to 13 yr. 5 mo.	14500
7 yr. 0 mo. to 7 yr. 5 mo.	18977	13 yr. 6 mo. to 13 yr. 11 mo.	
7 yr. 6 mo. to 7 yr. 11 mo.	18939	15 yr. 0 mo. to 15 yr. 5 mo.	15000

These observational means are shown as small circles in figure 31. The ordinates are the pounds of milk produced and the ages are the abscissas. From these observational means the logarithmic curve, shown as the smooth curve of figure 31, is calculated. The equation to this curve is

$$y = 11{,}351.5 + 873.67\,x - 32.225\,x^2 + 1548.36 \operatorname{Log} x$$

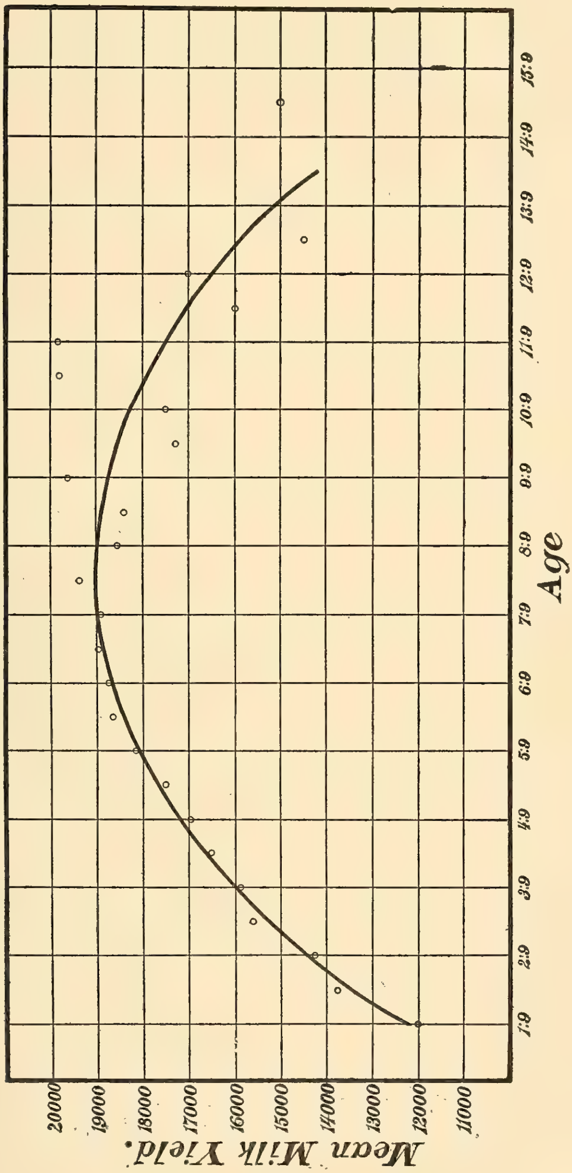

FIG. 31. Observational and fitted curves showing the relation of 365 day milk yield to age for Holstein-Friesian Cattle. The observational curve is represented by small circles. The smooth curve shows the fitted logarithmic curve for milk yield.

TABLE 3.

Correlation Surface Showing the Association of Age and the Butter-Fat Percentage of the 365 Day Record for Holstein-Friesian Cows.

Age at Commencement of Test

Butter-Fat Percentage	1:6–2:0	2:0	2:6	3:0	3:6	4:0	4:6	5:0	5:6	6:0	6:6	7:0	7:6	8:0	8:6	9:0	9:6	10:0	10:6	11:0	11:6	12:0	12:6	13:0	13:6	14:0	14:6	15:0–15:6	
2.3–2.4																													
2.4		1					1																						2
2.5		1										1																	2
2.6			1	2			3									1													7
2.7	1	5	4	2	5	2		2	3		1	1	3	1															30
2.8		8	3	3	6	4	3	4	3	1	2	1	3	2		1	2	1											47
2.9	2	17	6	10	7	6	9	11	1	6	3	1	1	1	2		2	1				1						1	88
3.0	5	30	18	11	17	10	10	9	10	9	8	8	2	7	1	5	1	2			1	1	1					1	167
3.1	4	45	21	22	26	15	19	26	9	16	9	13	7	3	7	2	3	1	1	1		1							251
3.2	4	60	24	10	21	28	24	22	25	15	10	10	4	8	6	5	2	4	2	3		1		1					289
3.3	14	54	43	36	37	22	15	28	23	19	21	18	5	11	12	5	5	2	2		1	1	2						376
3.4	6	60	42	21	33	18	22	15	25	20	14	13	6	11	9	5	5	5	3	2		1							336
3.5	13	59	31	31	22	16	32	20	20	14	15	9	9	6	4	2	4	4	4		2								317
3.6	9	45	31	17	23	16	13	16	13	16	7	2	6	3	4	4		1			1		1						228
3.7	3	45	29	14	10	16	11	9	4	4	3	1	7	4	1	1		2											164
3.8		21	19	10	6	7	8	8	5	7	2	1	1	4	1	4			1										105
3.9	4	7	8	7	8	6	4	6	5	4	4	2	1				1	1						1					69
4.0	4	4	6	3	2	5	5	3	3		4	2									1								40
4.1	1	6	5	1	2	1		3	1	1	1	2	1	1	1		1												28
4.2	1	2	3	1	2			1	1	1		1	1		2														16
4.3		3	2		1	1		2		2				1															12
4.4		2		1		3				1																			7
4.5				1			1	1		1																			4
4.6–4.7				1																									1
	71	475	296	204	228	176	180	186	149	137	104	86	57	63	50	35	26	24	13	6	6	6	4	2				2	2586

It will be noted that this curve strikes through the observations very well. The agreement between the observed and the theoretical curve is especially close for the milk yields of the younger cows. The considerable variation of the older cows in the observational mean curve is due to lack of numbers for the age classes. It will be observed that even here the theoretical curve strikes through the observations well.

By differentiation of the logarithmic equation to the milk yield it is possible to find the age at which the maximum productivity of these cows occurs. This is shown to be 8 years, 4 months and 29 days. While it is true that the change of mean milk yield is slight between the ages 6 years 6 months to 9 years 9 months, still it is equally true that the milk production of these advanced registry cows increase considerably over that given at 5 years. Such an increase is obviously unfair to those cows who are tested at five years in competition with those cows tested at 7 or 8 years.

Table 3 shows the association of 365 day mean butter-fat percentage with age for these same Holstein-Friesian cows. The interval chosen for age is the same as that for the table for milk production and age. The interval for butter-fat percentage is 0.1 of one per cent.

The mean age, the standard deviation and coefficient of variation for age of these cows is of course the same as that of table 1 given on page 189. The mean butter-fat percentage is 3.428; the standard deviation is 0.309. If we compare this coefficient of variation with that for the milk the coefficients are found to stand in the relation of 1 to 2.7. From this it may be argued that butter-fat percentage is much less variable within this group of Holstein-Friesian cows than is the milk yield. This conclusion is in practical agreement with that found for other data comparing milk yield and butter-fat percentage.

The correlation coefficient between butter-fat percentage and yield is $-0.0675 \pm .0133$. The correlation coefficient is consequently slightly significant.

The mean butter-fat percentage for the different age groups as exhibited in table 3 are shown in table 4.

TABLE 4.

Mean 365 Day Butter-Fat Percentage of Holstein-Friesian Cows at Different Ages.

Age at Test	Mean Butter-Fat Percentage	Age at Test	Mean Butter-Fat Percentage
1 yr. 6 mo. to 1 yr. 11 mo.	3.489	8 yr. 0 mo. to 8 yr. 5 mo.	3.399
2 yr. 0 mo. to 2 yr. 5 mo.	3.432	8 yr. 6 mo. to 8 yr. 11 mo.	3.416
2 yr. 6 mo. to 2 yr. 11 mo.	3.483	9 yr. 0 mo. to 9 yr. 5 mo.	3.376
3 yr. 0 mo. to 3 yr. 5 mo.	3.442	9 yr. 6 mo. to 9 yr. 11 mo.	3.342
3 yr. 6 mo. to 3 yr. 11 mo.	3.398	10 yr. 0 mo. to 10 yr. 5 mo.	3.388
4 yr. 0 mo. to 4 yr. 5 mo.	3.449	10 yr. 6 mo. to 10 yr. 11 mo.	3.442
4 yr. 6 mo. to 4 yr. 11 mo.	3.409	11 yr. 0 mo. to 11 yr. 5 mo.	3.300
5 yr. 0 mo. to 5 yr. 5 mo.	3.417	11 yr. 6 mo. to 11 yr. 11 mo.	3.533
5 yr. 6 mo. to 5 yr. 11 mo.	3.410	12 yr. 0 mo. to 12 yr. 5 mo.	3.200
6 yr. 0 mo. to 6 yr. 5 mo.	3.443	12 yr. 6 mo. to 12 yr. 11 mo.	3.350
6 yr. 6 mo. to 6 yr. 11 mo.	3.414	13 yr. 0 mo. to 13 yr. 5 mo.	3.600
7 yr. 0 mo. to 7 yr. 5 mo.	3.366	13 yr. 6 mo. to 13 yr. 11 mo.	
7 yr. 6 mo. to 7 yr. 11 mo.	3.415	15 yr. 0 mo. to 15 yr. 5 mo.	3.000

These observational means are shown as the small circles in figure 32. The ordinates are the percentages of butter-fat and the abscissas are the ages. These observations on butter-fat percentage clearly are linear in their relation to age when the test was made. Such being the case the ordinary regression formula may be used to fit this curve. The equation to this curve is

$$\text{Butter-Fat Percentage} = 3.470 - .009 \text{ age}$$

There is consequently a slight decrease in the butter-fat percentage which a Holstein-Friesian cow is capable of giving as the age of that cow increases. That this increase is slight may be seen from the fact that the decrease in butter-fat percentage from the age of one year and nine months is only 0.130 per cent as shown by the fitted curve of the above figure.

These conclusions concerning the milk yield and the butter-fat percentage make it possible to answer a number of practical questions which are today occupying prominent places in our dairy husbandry. Perhaps one of the most interesting concerns the admission of cows into the advanced registry. In the advanced registry work the linear nature of the butter-fat requirement has already been mentioned. In view of the fact that milk yield in Holstein-Friesian cows is a logarithmic function of age instead of a linear one and that butter-fat percentage has only a slight relation to age it follows that butter-fat is a logarithmic

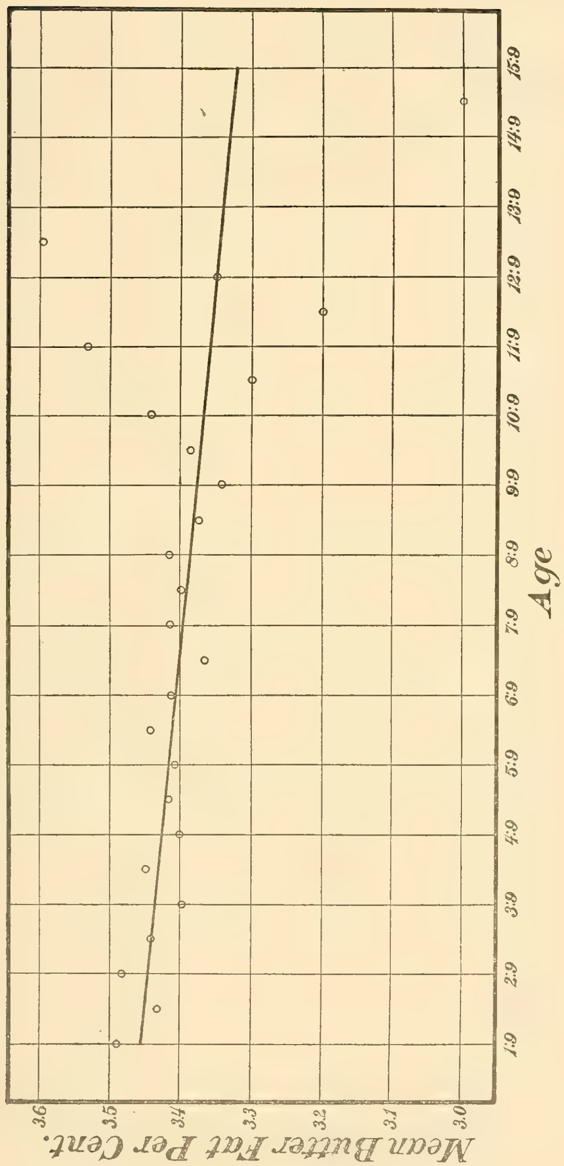

FIG. 32. Observational and fitted curve showing the relation of 365 day Butter-fat percentage to age for Holstein-Friesian Cattle. The observational curve is represented by small circles. The smooth curve shows the fitted line curve for milk yield.

function of age since butter-fat is in truth only the multiple between the milk yield and the butter-fat percentage.

When the calculations are made it is found that the cows commencing their test under 2 years of age are at the greatest handicap. From two years to four years and six months the handicap becomes progressively less. Between four years and six months and five years the handicap is increased by about 1.5 pounds of butter-fat. From five years of age the cow's butter-fat production rises rather rapidly to her maximum yield at about eight years and two months. (This maximum for the butter-fat is somewhat earlier than is the maximum for milk due to the slight decline of the butter-fat percentage with age). From the age of maximum butter-fat production there is a marked decline in the butter-fat as the age of the cow advanced. This decline handicaps the aged cow as compared with one at 7 to 8 years old.

This information allows certain conclusions to be drawn relative to the desirable age at which to commence the advanced registry test for the cow. The most favorable period is between the ages six and one-half years and 9 and one-half years. At this time the average advanced registry cow needs about 80 pounds less butter-fat than she would need as a two year old to make a record sufficient for her to enter into the advanced registry. Other differences are perhaps as striking. At the five year old age the requirement for that age gives the average advanced registry cow about thirty pounds of butter-fat handicap over the cow commencing her test as a two year old.

BULLETIN 294

NORMAL AND ABNORMAL GERMINATION OF GRASS—FRUITS.*

BY

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SUMMARY

The present paper is an account of the processes that take place at the time of emergence of the radicle of hulled grass-fruits from the surrounding tissues.

The penetration of the germinating embryo through the tissues of the adhering pericarp is a purely mechanical process. Under the pressure of the extending embryo a section of the tissues yields at a certain point and usually in a certain direction.

At normal germination the coleorhiza breaks through the base of the fertile glume within a zone whose mechanical resistance is greatly lessened by the marked reduction and differentiation of the epidermal and hypodermal mechanical cells. The prosenchymatous tissue yields along lines of contact of the long sclerenchymatous cells and the short basal elements of the glume. Likewise, the epidermis is ruptured in a region where cells marked by different morphological forms and physical structure meet. In both cases the cells are pushed apart, the sclerenchymatous cells remaining, as a rule, intact while the epidermal cells mostly escape injury. The tracheal elements of the fibro-vascular bundles have been invariably found to be broken through.

The abnormal germination of hulled grass-fruits is caused by external mechanical factors prevailing in artificial germination media which operate so as to thwart and eliminate the

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*This is an abstract from a paper by the author having the title: "Ein Beitrag zur Keimungsgeschichte der bespelzten Grassfrüchte," and published in "Mitteilungen der landw. Lehrkanzeln der K. K. Hochschule für Bodenkultur," Vol. II, pp. 675-712, 8 pl. 24 figs. Wien, 1914.

growth tendency of the radicle in the normal direction. As a result of this interaction between normal growth-tendency and growth-inhibition the radicle takes its way in the direction of least resistance.

At germination in natural media in the soil, the factors obtaining in artificial germinators are not present and accordingly the abnormal germination is either entirely absent or occurs only to a very limited degree with some grasses.

Likewise, the second consequence of the operation of conditions prevailing in the germinator, i. e. the dying off of the radicle within the glumes, either does not occur at all or only very rarely at germination in the soil.

The rupture of the tissues of the glumes is effected, as a rule, by the coleorhiza. It accomplishes this chiefly by means of its turgescence and may be assisted in this work by the short and thick cells of its apical tissues.

The chief function of the coleorhiza is its mechanical performance in breaking through the tissues of the glume, it further functions as a protective organ for the tender radicle and cares by means of its hairs or trichomes for the fastening of the seedling to the soil particles, thus assisting the radicle in its penetration into the soil.

The occurrence of the trichomes as observed in the course of the investigation in a large number of grasses justifies the conclusion that the formation of hairs is a general characteristic of the coleorhiza of the Gramineae.

The radicle emerges from the coleorhiza of grass-fruits through a longitudinal, lateral opening formed by the cells being detached and pushed apart without being injured in any way.

INTRODUCTION.

The anatomical and mechanical processes accompanying the passage of the germinating embryo through the glumes of the grass-fruits, especially of the true grasses, have hitherto been given but little attention. Although the germination of the Gramineae has long been studied with great interest, the chief attention was centered on the cereals while the true grasses were generally subordinated to them.

The presence of flowering glumes and—in certain species—sterile glumes enclosing the caryopsis, the development of long and thick trichomes on the coleorhiza of grass-fruits as compared with the short and scant hairs on the coleorhiza of cereals, the sending out, at the beginning of germination, of the main radicle alone instead of several rootlets as in the case of the germinating caryopsis of cereals, and finally the various types of abnormal germination reported in this paper, are all features peculiar to the true grasses and interesting enough to warrant a separate consideration of the germination of grass-fruits.

The present account is an attempt to follow the germinating embryo of the hulled grass-fruits on its way through the surrounding tissues, and to record the anatomical changes and mechanical processes accompanying germination.

The changes in the anatomy of the pericarp caused by the germinating embryo have not been examined in this study.

The material for this investigation comprises chiefly the economically important grasses. In the course of this study over 18,000 seedlings were examined. The illustrations, some of them hand drawings from nature, were all made by the writer.

I. NORMAL GERMINATION OF GRASS-FRUITS.

1. THE PENETRATION OF THE COLEORHIZA THROUGH THE PERICARP.

The first stages of the process of germination of the hulled grass-fruits take place in a manner similar to the general type of the Gramineae. Germination begins with the absorption of water. The germ becomes turgescent and lies now close to the pericarp. Contrary to the germination of the Cyperaceae and some other monocotyledonous plants the first symptoms of growth are normally visible at the base of the embryo. First the coleorhiza extends and strikes upon the pericarp. No record is available of the anatomical changes in the pericarpial tissues caused by the breaking through of the coleorhiza. Nor are the macroscopic descriptions of this stage in the germination concordant.

The few references to be found in the literature do not indicate which part of the embryo breaks through the pericarp. If the embryonic region of a naked caryopsis of Alopecurus or Arrhenatherum be examined with a low power lens at the first stage of germination, it will be noticed that under the pressure of the extending coleorhiza a small aperture is formed above the hilum in which the tip of the coleorhiza appears. This aperture soon gives rise to a slit which tends upwards, usually in the middle plane of the embryo, and grows wider being extended by the growing coleoptile up to the inner edge of the scutellum. On removing the germinating embryo from the caryopsis a more or less elliptical opening will be seen with the separated edges of the pericarp projecting over it. Thus the rupture of the pericarp takes place usually in a definite direction and, as a rule, is effected by the extending coleorhiza. During this process no loss of tissues occurs. This is worthy of being mentioned since one might be inclined to assume in connection with this process the operation of chemical agencies that would loosen and absorb the tissue elements.

2. THE PENETRATION OF THE COLEORHIZA THROUGH THE LEMMA.

After breaking through the tissues of the pericarp the coleorhiza encounters the basal wall of the fertile glume or lemma. The basal region of the lemma presents a detail of special importance in connection with the breaking through of the coleorhiza. At its base the lemma of the grass-fruits forms a semiglobular, disk-like or obtuse-conical callus which is separated from the main body of the lemma by a transverse furrow, and which is connected with the rachilla by means of a joint. In this region a marked differentiation of tissues occurs. Before describing the anatomical details of this region it is advisable first to briefly discuss the tissue elements of the lemma.

The lemma is composed of the outer and inner epidermis and of the mesophyll enclosed by them. The elements of the outer epidermis which forms the most powerful part of the lemma in most grasses, are distinguished by their wavy longitudinal walls whose indentations are most pronounced in the middle section of the lemma. Here, as will be seen in Fig. 33

the wavy lines of the longitudinal cell-walls are transformed into transverse processes, which with some grasses attain a length equaling the width of the cell. These transverse processes of the longitudinal walls fit into the corresponding indentations of the adjoining cells thus establishing a mechanical resistance of this system of tissues in the longitudinal direction. Embedded in between the longitudinal walls of the adjoining cells are thick silicious cells, one-celled and two-celled little hairs. These function as rivets, so to speak, establishing a connection of the cells in the longitudinal direction and preventing a dislodging of the epidermal cells in the transverse direction. The mechanical firmness of this system of tissues is further enhanced by the thickening and silicifying of the cells. The mesophyll beneath the epidermis is differentiated into two layers: The prosenchyma composed of specific mechanical cells and the parenchyma made up by thin-walled cells carrying chlorophyll at their early stage of growth. The prosenchyma is composed of elongated, very thick, porous, spindle-shaped cells, (Fig. 35, C.) which owing to their very marked growth in the longitudinal direction, interlock with each other. (Fig. 35, A.). The lemma of the true grasses contains usually 1-3 layers of these cells. The number of layers of parenchymatous cells increases towards the vascular bundles. As will be seen later this increase in parenchymatous tissue around the vascular bundles and at the base of the lemma is of importance in connection with the breaking through of the coleorhiza. Beyond the marginal vascular bundles the cells of the parenchyma become thick-walled, their lumen decreases as well as their number until at the edge of the lemma they disappear. The sclerenchymatous cells undergo a similar reduction so that at the lower outer edge of the lemma the thick-walled cells of both the outer and inner epidermis lie upon each other.

The inner epidermis is composed of thin-walled, elongated, colorless cells, possessing, when young, a very large lumen.

The differences in thickness and tenacity of the lemmas of different grasses is caused by the variation in the number of cell layers and the degree of thickening of the elements of the outer epidermis and the prosenchyma.

Returning now to the processes occurring during the first stages of germination, the coleorhiza, after breaking through the pericarp, directs the energy of its turgescent cells against the

mechanical resistance of the basal zone of the lemma. The turgor increases with the growing activity of the coleorhiza and reaches a point, when it equals the resistance of the lemma. If the coleorhiza is now to effect the breaking through the lemma it is essential that the caryopsis be properly anchored so as to avoid its being pushed back or aside by the presence of the extending coleorhiza. Normally, the caryopsis at germination in artificial media is prevented from receding by its firm cohesion to the palet, and occasionally, to the lemma. The pressure of the coleorhiza exerted against the base of the lemma finally overcomes the resistance of the latter and a rupture of the tissus in that region ensues.

The macroscopic aspect of the rupture at the base of the lemma varies somewhat with different grasses but with the same species it always occurs in a definite manner. On examining the germinating caryopsis of *Lolium italicum* or *Festuca arundinacea* just previous to the appearance of the tip of the coleorhiza, it will be noticed that the primary fissure runs in a transverse direction, generally along the basal furrow above the callus referred to above. Soon after, the pressure of the protruding coleorhiza causes the tissues at the base of the lemma to split forming longitudinal slits which extend upwards for some distance. The section of the lemma, severed from its base by the coleorhiza, may either be bent off as a coherent piece *(Lolium italicum, Festuca arundinacea, Panicum miliaceum)* or split into more or less wide stripes (Arrhenatherum, Dactylis, Avena, Holcus). The primary transverse fissure was never found to extend beyond the marginal vascular bundle.

While these conditions are typical of the majority of hulled grass-fruits, the coleorhiza of certain grasses breaks through the lemma in a manner somewhat different from the one just described, and characterized by the longitudinal slit occurring in a distinct region and direction. To this group belong grasses whose caryopsis and glumes are flattened, the embryo facing the strongly carinated, dorsal, fibrovascular bundle of the lemma, e. g. *Alopecurus pratensis, A. geniculatus* and *A. agrestis, Phalaris arundinacea* and *canariensis, Oryza sativa* and *Bromus Schraderi.* Here the rupture of the lemma occurs along a line of contact of the parenchyma and the median fibrovascular bundle. With the exception of a few cases—in the glume of

Alopecurus pratensis, and *A. agrestis,* and the lemma of *Oryza sativa,*—the writer has not observed a splitting of the fibrovascular bundle, at germination. The separation of the fibrovascular bundle from the parenchyma may be observed very distinctly in *Phalaris arundinacea* and *Phalaris canariensis.* Here two types of cleavage may occur. The coleorhiza may, like in Alopecurus, either cause a slit which is continued along the fibrovascular bundle, or, the median fibrovascular bundle may be ruptured at the base of the lemma and separated from the latter by two parallel longitudinal slits running along its sides. With Alopecurus the tissue at the base is not ruptured at germination probably on account of the flattened, spatula-like shape of the coleorhiza whose pressure is directed against only a narrow zone, in the plane of the median vascular bundle.

The penetration of the coleorhiza through the powerful obstacle presented by the lemma would require such a considerable effort that one must assume the presence of certain arrangements in the structure of the lemma, tending to reduce its resistance and facilitate the task of the coleorhiza. An investigation into the tissues of the lemma revealed a very marked differentiation and reduction of the tissues in the basal region of the lemma.

Considering first the tissues of the lemma of *Lolium italicum,* it will be seen that the epidermis, throughout the greater part of the lemma is built with a view to mechanical firmness (Fig. 33.). Towards the base, however, the jagged processes of the longitudinal walls of the epidermal cells decrease and ultimately disappear, the walls assuming a wavy aspect. The silicious cells likewise disappear so that here the contiguous epidermal cells touch each other directly with their septae. In the proximity of the base of the lemma the epidermal cells become thin-walled, their longitudinal and transverse diameter decrease and finally they assume the aspect illustrated in Fig. 34 (upper part). A comparison of Fig. 33 with Fig. 34 will afford sufficient evidence of the changes in the epidermal cells. After forming the transverse basal groove the epidermal cells enter the basal callus.

The callus presents a very interesting anatomical detail. With *Lolium italicum* it has a flat semi-globular form, and over its upper edge extend the above-named super-basal cells of the

epidermis which at this point assume an irregular and peculiar shape (Fig. 34, lower part). They appear here short and broad, and have a more transverse orientation, which is of importance in connection with the breaking through of the coleorhiza. Following these cells is a layer of strongly thickened, silicious, mainly hexagonal cells. They lie parallel to each other and are, about the middle of the base, arranged in longitudinal series while at either side of the base they form transverse, fan-like layers. These cells terminate with a ring of quite short, roundish-polygonal cells which form the outermost lower border of the base of the lemma. With this ring of short cells the lemma rests upon the rachilla. The rachilla appears as a columnar pillar whose elements are composed of elongated cells. The epidermal cells are very thick, appear round on cross-section, and some of them run out into hairs. The epidermis is followed by 2 to 3 layers of thick-walled, pitted, sclerenchymatous cells while the parenchymtous tissue fills out the central part of the rachilla, and surrounds the fibrovascular bundles. Towards the base of the lemma the rachilla broadens somewhat and its long cells terminate with a ring of quite short round cells which border directly on the ring of similarly developed cells forming the lowermost layer of the base of the lemma. At maturity these two rings separate and the fruit thus becomes detached from the rachilla.

No less striking is the differentiation of the mechanical elements of the prosenchymatous tissue. As will be seen from Fig. 35 A. a. C. this tissue is composed above the basal region of the lemma of elongated, interlocking, pointed sclerenchymatous cells. At the base, however, they lose their sclerenchymatous aspect, their longitudinal diameter decreases, their lumen increases, their pointed ends are transformed into oblique or almost horizontal septae until they assume an entirely different aspect at the base of the lemma, as illustrated in Fig. 35 B.

This differentiation in form is accompanied by a reduction in the number of presenchymatous cell-layers in the region where the coleorhiza breaks through. While above the base the prosenchyma is composed of 5-7 layers, it is reduced at the base to but one layer. The reduction of the epidermis is also caused by the disappearance of silicious cells and the decrease in the thickness of the cell walls. However, along the outer edge of the

marginal fibrovascular bundles in the lower region of the lemma, the prosenchyma forms a strong layer of mechanical cells, which enter the base and penetrate it transversely. A part of them resolve themselves about the middle of the base into short cells. while most of them connect with the tissues of the rachilla bearing the upper spikelet. This rachilla has a pillar-like form composed of long, pitted, cells which terminate at the apex with a ring of short cells upon which the base of the upper spikelet rests. Towards its lower end the rachilla broadens and enters the base of the lemma of the lower spikelet. Its central tissue runs out into small cells while the lateral cell layers on entering the base of the lemma of the lower spikelet turn outwards, become short-celled, and join the lateral layers of the base referred to above. The point of juncture of these two cords of tissues affords a very interesting mechanica detail. Here peculiar knee-shaped cells are found which penetrate with their pointed ends into the intercellular spaces of the two tissue-cords thus establishing a joint btween the base of the lemma of the lower and the rachilla of the upper spikelet. This hinge-like detail enables the lemma to execute a turning movement at the time of bloom.

To complete the description of the base of the lemma it may be added that here we find the point of junction of the fibrovascular bundles. The three fibrovascular cords on entering the base branch out, five bundles entering the lemma while the remainder goes off to the upper rachilla and palet.

The changes in the epidermis and prosenchyma occuring at the base of the lemma can also be studied on transverse sections. (See Figs. 36, 37, 38). Fig. 36 represents a section below the point at which the coleorhiza breaks through, showing the thick-walled, pitted cells of the outer epidermis and the likewise thick-walled cells of the prosenchyma. Fig. 37, illustrates a cross-section of the base of *Festuca arundinacea,* about the line of rupture. Here a remarkable differentiation in the direction of the transverse axis can be noticed. The cells of the prosenchyma to the right of the lateral fibrovascular bundle, towards the median bundle, become thick-walled and finally assume a sclerenchymatous aspect while towards the marginal nerve they possess thin walls and differ little from the parenchymatous tissue. The latter decreases towards the median bundle and finally becomes reduced to 2 layers. From the lateral fibrovascular bundle to the marginal the paren-

chyma gradually increases, attaining its greatest extention near the marginal bundle. Thus the parenchyma predominates in the region between the lateral and marginal vascular bundles and as a result the tissue of the lemma of *Festuca arundinacea* and other grasses is ruptured by the coleorhiza between these two fibrovascular bundles.

The very remarkable aspect which the tissues of the lemma assume above the line of rupture is illustrated in Fig. 38 which represents a section between the lateral and marginal fibrovascular bundles, corresponding to the one given in Fig. 37 (around the median bundle.) A comparison of Fig. 38 with Fig. 37 shows the powerful development of the epidermis and prosenchyma composed here of strongly thickened cells possessing a small lumen. On the other hand, the parenchyma is reduced to two or at the most, near the vascular bundles, to three cell layers. The cells of the inner epidermis possess a small lumen and are compressed transversely.

The conditions found in *Lolium italicum* and *Festuca arundinacea* are typical of the other grasses.

Having described the nature of the tissue at the base of the lemma it will now be of interest to discuss the manner in which these tissues are affected by the penetrating coleorhiza of the germinating embryo. Under the pressure of the coleorhiza the thin-walled cells of the inner epidermis and the parenchyma are stripped off and frequently distorted. Next the coleorhiza strikes upon the prosenchymatous tissue. Under its pressure the cells of the prosenchyma are moved apart along the line of juncture of the long sclerenchymatous and the short cells of the base, there occurring no injury to the cells. As illustrated in Fig. 35 B this line runs along the oblique or transversal septae of the sclerenchymatous cells which remain completely intact. The spaces between the projecting ends of these cells were originally occupied by the short cells of the base of the lemma. Occasionally a few of these short basal cells adhere to the sclerenchymatous cells after the coleorhiza has broken through. (Fig. 35B, bb.)

The cells of the outer epidermis behave in a similar manner. Here the separation of tissues occurs along a line at which two series of cells differing as to form and physical characteristics meet, the thin-walled, almost transversely lying cells of the

lemma being separated from the strongly thickened, silicified cells of the base.

While these conditions are typical of Lolium, Festuca, Arrhenatherum, etc. it occasionally occurs with other grasses that the cells of the epidermis are rent by the coleorhiza.

The formation of the longitudinal slits is facilitated by the absence of the transverse processes of the walls and the lack of silicious cells at the base of the lemma. In yielding to the pressure of the coleorhiza in the longitudinal direction the cells of the epidermis and prosenchyma are pushed apart, the former remaining usually, the later as a rule, intact. (Fig. 34). These slits very often run along the fibrovascular bundles, where the thin-walled parenchyma occurs in several layers.

It should be added that the tracheal tissues are broken through transversely and separated from the base of the lemma.

Abnormal Germination of Grass-Fruits.

Under normal conditions of germination the coleorhiza or the radicle appear first, and, as a rule, at the base of the lemma. At the beginning of this investigation several cases were observed of hulled grass-fruits developing first the coleoptile while nothing was to be seen at first of the radicle. A study of these cases brought out the fact that a majority of hulled grass-fruits show this type of germination which involves no physiological disturbance, but is the result of external factors, like mechanical resistance to and retardation of growth. The common feature of these abnormal cases is that the radicle does not break through at the base of the lemma. The different modes of abnormal germination have arbitrarily been arranged here in two groups.

Type A. The radicle appears either at the tip of the glumes or in the opening between the lemma and palet, below the tip of the lemma. The coleoptile appears, as a rule, outside the glumes sometime before the radicle emerges.

The following reasons account for the coleoptile appearing ahead of the radicle. The radicle growing first downwards, then bending at the base upwards covers in all cases a longer distance than the upwards growing coleoptile. In many cases the lemma is bent from the caryopsis thus exposing the coleoptile. Further, the caryopsis may be lifted by the pressure of the radicle; this

not only causes the coleoptile to appear first but also prolongs the distance covered by the radicle which first grows downwards to bend upwards on striking the base of the lemma. However, in several cases of abnormal germination the radicle was observed to appear ahead of the coleoptile (Arrhenatherum, Alopecurus, Dactylis, Lolium, Poa.)

Within Type A two forms of abnormal germination may be distinguished.

1. The lemma is bent from the caryopsis by a larger or lesser angle. The caryopsis is not raised in the glumes.

The majority of the abnormally germinating fruits show this type of germination. (Lolium, Festuca, Poa, Cynosurus, Agrostis). The angle at which the lemma is bent from the caryopsis varies generally from 45° to 90°. With *Setaria germanica* and *Phleum pratense* this angle may reach almost 180°. The radicle, emerging from the coleorhiza strikes upon the wall of the lemma, curves upwards and growing along the inner wall of the lemma appears at the tip of the latter.

2. The lemma adheres to the caryopsis or is slightly bent from it. The caryopsis, as a rule, is raised in the glumes.

Alopecurus, Arrhenatherum, Holcus, Anthoxanthum, Avena, etc. show this type of abnormal germination. The extending coleorhiza, on striking the base of the lemma, raises the caryopsis a short distance. The protruding radicle pushes first the caryopsis farther up, then bends upwards at a very sharp angle to appear at the apex of the glumes.

Anthoxanthum, Holcus and Alopecurus, which are surrounded also by the sterile glumes may exhibit a type of abnormal germination illustrated in Fig. 40. The radicle breaks through normally at the base of the lemma (Fig. 40B) and striking upon the base of the sterile glume turns upwards and appears between the tips of the sterile glumes.

Type B. The radicle does not appear at the apex of the glumes but directing its point against the base of the lemma it pushes the caryopsis out of the glumes and away for some distance. Figs. 39 and 44 illustrate this type of abnormal germination. With fruits enclosed also by the sterile glumes the radicle may push out the caryopsis alone (Fig. 39) or it may break through in the normal way at the base of the lemma and

TABLE 1.

Kind of Grass	KIND OF GERMINATION: Normal	Radicle appears at apex of fertile glumes: Lemma bent off	Radicle appears at apex of fertile glumes: Lemma adhering to caryopsis	Radicle appears between tips of fertile or sterile glumes: Lemma and sterile glumes intact	Radicle appears between tips of fertile or sterile glumes: Base of lemma broken through sterile glume intact	Caryopsis pushed away from fertile glumes; apex of radicle at base of lemma	Caryopsis with fertile glumes pushed out of sterile glumes; apex of radicle at base of sterile glumes	Radicle stunted or dead within fertile or sterile glumes	Frequency of all kinds of abnormal germination
	Expressed in Percentage of Total Germinated Grass-Fruits								
Alopecurus pratensis (Meadow Foxtail)	50.3			15.6		14.9		19.1	30.5
Alopecurus agrestis	86.0			11.0				3.0	11.0
Alopecurus geniculatus (Floating Foxtail)	54.2			7.0	2.2	16.2		20.4	25.3
Anthoxanthum adoratum (Sweet vernal-grass)	52.0			22.5	4.0	7.3	11.8	1.7	45.6
Arrhenatherum elatius (Oat grass)	25.0		11.0			63.5		0.5	74.5
Avena pubescens	82.7	11.9				1.2		4.1	13.1
Cynosurus cristatus (Crested Dogstail)	84.0	12.3				2.3		1.4	14.6
Dactylis glomerota (Orchard grass)	70.7	19.8				6.9		2.5	26.7
Festuca arundinacea (Reed Fescue)									
Festuca ovina (Sheep's Fescue)	79.5	13.5	3.8						17.3
Festuca pratensis (Meadow Fescue)	55.2	6.6	22.5						29.2

TABLE 1—Concluded.

Kind of Grass	KIND OF GERMINATION								
	Normal	Radicle appears at apex of fertile glumes		Radicle appears between tips of fertile or sterile glumes		Caryopsis pushed away from fertile glumes; apex of radicle at base of lemma	Caryopsis with fertile glumes pushed out of sterile glumes: apex of radicle at base of sterile glumes	Radicle stunted or dead within fertile or sterile glumes	Frequency of all kinds of abnormal germination
		Lemma bent off	Lemma adhering to caryopsis	Lemma and sterile glumes intact	Base of lemma broken through sterile glume intact				
	Expressed in Percentage of Total Germinated Grass-Fruits								
	85.0	13.0							13.0
Holcus lanatus (Velvet grass)	25.0			18.3	21.7	6.6		28.3	46.6
Lolium italicum (Italian Rye grass)	95.3	1.2	1.8						3.0
Lolium perenne (Perennial Rye grass)	85.3	14.2							14.2
Phalaris arundinacea (Reed Canary grass)	90.7	5.3				1.3		2.6	6.6
Phalaris canariensis (Canary grass)	93.1	2.3				2.9		1.7	5.2
Poa compressa (Canada Blue grass)	27.7	61.0				4.5		6.8	65.5
Poa nemoralis (Wood Meadow grass)	3.7	87.5				1.0		7.8	88.5
Poa pratensis (Kentucky Blue grass)	46.6	39.7						13.5	39.7
Poa trivialis (Rough-stalked Meadow grass)	63.2	32.7						4.0	32.7

move away the caryopsis, enclosed in the lemma and palet, from the sterile glumes.

Asssociated with the abnormal germination is a marked tendency to develop adventitious rootlets which spring from the hypocotyl or mesocotyl. This tendency is a result of the retardation in the growth of the primary radicle and reaches its highest degree in cases where the primary radicle becomes stunted and dies off. The frequently observed stunting and dying off of the radicle was found to be due to abnormal germination rather than to deficient viability.

In Table 1 is given the frequency occurrence of the normal and abnormal germination of fruits of twenty grasses. From this table the high percentage of abnormal germination in Arrhenatherum, *Poa nemoralis* and *Poa compressa,* Holcus lanatus will be noted. This table also shows a varying percentage of stunted or dead radicles, being highest with grass fruits which in addition to the fertile glume are surrounded, at germination, also by the sterile glumes.

In view of the high percentage of abnormal germination it became a matter of practical importance to determine whether this phenomenon occurs under natural conditions of germination in the soil. With this end in view a series of germination experiments were carried out with fruits of 9 grasses sown in pots filled with soil, the results of which are given in Table 2.

TABLE 2.

Kind of Grass	Number of fruits sown	Normal Germination	Abnormal Germination	Radicle died off within glumes
		Per cent of Germinated Fruits		
Alopecurus pratensis	400	98.0		1.7
Arrhenatherum elatius	100	100.0		
Cynosurus cristatus	100	100.0		
Dactylis glomerata	100	100.0		
Festuca arundinacea	400	99.0	0.3	0.6
Festuca ovina	100	100.0		
Holcus lanatus	200	90.0	6.0	3.0
Lolium italicum	200	100.0		
Lolium perenne	200	96.8	3.2	

The results presented in Table 2 show that under natural conditions prevailing in the soil abnormal germination either does not occur at all or only with a few grasses to a very slight

extent. On comparing Table 2 with Table 1 it will be seen that the stunting and dying off of the radicle within the glume is likewise occasioned by the artificial conditions prevailing in the germinator, and hardly occurs in the soil.

Before discussing briefly the causes of abnormal germination attention should be called to the fact that if a growing organism is to effect a certain performance it is essential that it be sufficiently anchored to prevent its being pushed back or bent aside. If this is not the case the organ will grow in the direction of least resistance.

Another point to be emphasized is that normally it is the coleorhiza that breaks through the tissues of the lemma. If the coleorhiza fails in this important function the conditions for abnormal germination are fulfilled.

Considering the most frequently occurring form of abnormal germination, where the lemma is bent from the caryopsis, it is obvious that here the pressure of the extending coleorhiza does not reach the intensity required to break through the base of the lemma. It does, however, reach an intensity sufficient to bend the lemma away from the caryopsis. The coleorhiza thus effects a performance in the direction of lesser resistance and the radicle, after escaping from the coleorhiza, is unable to penetrate the lemma and grows along the inner surface of the latter.

The same mechanical cause, though attended by a different external effect, brings about the other irregularities of abnormal germination. In those cases where the caryopsis is raised in the glumes the effort of the extending coleorhiza to break through the lemma is annulled by the caryopsis receding under pressure from the base of the lemma. The radicle upon leaving the coleorhiza may in turn raise the caryopsis somewhat and then bend upwards and appear at the tip of the glumes, or it may remain with its apex at the base of the glumes and push the caryopsis out and away sometimes for several centimeters from the glumes.

The degree of adhesion of the glumes to the caryopsis determines the kind of abnormal germination and is in turn influenced by the amount of moisture available in the germinator.

A quite distinct form of abnormal germination is shown by *Oryza sativa*. In a majority of examined seedlings it was found that the first signs of growth at germination are shown by the

coleoptile. Under the pressure of the epiblast the median vein or fibrovascular bundle yields, and in the narrow elliptical opening appear the coleoptile and the tip of the epiblast. This aperture extends downward, and the coleoptile shows several milimeters outside the glumes when the coleorhiza appears. Thus with *Oryza sativa* the coleorhiza and the coleoptile escape through the same opening.

III. THE MECHANICAL AND BIOLOGICAL FUNCTION OF THE COLEORHIZA.

A brief description of the structure of the coleorhiza may serve to understand its functions.

The coleorhiza has the shape of a truncate cone. Its tissues consist of a mass of uniform cells covered by an epidermis extending to the apex of the coleorhiza. The form of the cells varies according to the stage of elongation of the coleorhiza. After the coleorhiza breaks through the glumes its cells appear in the middle section longitudinally extended, utricular, becoming shorter in the proximity of the apex terminating by thickened cells of the apical appendage. (Figs. 41 and 42).

The function of the coleorhiza is primarily mechanical in that it breaks the way for the radicle. It acts also as a protecting organ for the radicle. Nor is its function over with the penetration through the tissues of the glume. Soon after the coleorhiza breaks through the glume it sends out numerous trichomes or hairs whose length depends upon the grass species and the stage of gemination. These trichomes attain their greatest length at time when the radicle comes in contact with the soil or other substratum.

The trichomes act as fastening organs clinging to the particles of soil or other substratum, thus anchoring the germinating fruit.

In this investigation trichomes were observed on the coleorhiza of the following grasses: *Alopecurus pratensis, Alopecurus geniculatus, Alopecurus agrestis, Arrhenatherum elatius, Anthoxanthum adoratum, Anthoxanthum Puelii, Avena pubescens. Bromus Schraderi, Bromus arvensis, Brachypodium sylvaticum. Cynosurus, Dactylis glomerata, Elymus arenarius, Festuca pratensis, Festuca ovina, Festuca arundinacea, Festuca heterophylla,*

Festuca rubra, Holcus lanatus, Koeleria cristata, Lolium italicum, Lolium perenne, Oryza sativa, Poa pratensis, Poa trivialis, Poa compressa, Setaria germanica and *Phalaris arundinacea.*

After the coleorhiza has fulfilled its functions it is in turn broken through by the radicle. The radicle escapes from the coleorhiza through a lateral opening below the apex of the coleorhiza. Under the pressure of the radicle the cells of the coleorhiza become detached and are pushed apart without being injured.

POLYEMBRYONY IN GRASSES.

In the course of the present investigation the writer observed polyembryony in *Arrhenatherum elatius, Poa pratensis, Poa nemoralis,* and *Poa compressa.*

Diembryony occurred most frequently in *Poa pratensis,* (Fig. 43) with only two cases of fruits developing three embryos. Two cases of diembryony have been observed in Poa nemoralis and one case in Poa compressa.

A particularly fine case of diembryony has been observed in *Arrhenatherum elatius.* (See Fig. 44.) The individual seedlings were equally well developed and were united at the base of the hypocotyl possessing separate normal organs. As will be seen from Fig. 44 the emergence of the seedlings out of the glumes occurred in an abnormal manner, but their subsequent development was normal. It may be stated in this connection that in practically all cases of polyembryony the radicles emerged abnormally from the glumes.

ABNORMAL GERMINATION AS A POSSIBLE SOURCE OF ERRORS IN RECORDING RESULTS OF GERMINATION TESTS.

From a practical point of view some of the results of this investigation may have some significance in connection with the determination of the viability of grass seeds as determined by the germination test. The seeds of certain grasses are rather exacting as to conditions of germination, and the question of the influence of temperature, light and other physiological factors upon the germination of grass seeds still constitutes an important problem for research. It is then obviously important,

in the interest of greater accuracy and uniformity in recording results of germination tests, to determine the possible influence of any deviation in the germination from the normal upon the practical valuation of the viability of seeds as established by the germination test.

Two kinds of abnormality occur at germination of grass seeds on top of blotters: (a) the abnormal emergence of the radicle, and (b) the stunting and dying off of the radicle within the glumes. Relative to the first abnormality the germination test is usually carried for a sufficient length of time to allow the abnormally emerging radicle to appear at the tip of the glumes, and thus to become visible to the eye of the examiner. Such seeds should be considered as viable and otherwise normal since upon placing them in the soil they will grow normally.

The stunting and dying off of the radicle within the glumes, presents a more serious possibility of making errors in recording results of germination tests. Reference to Table 1 reveals that some of the grass seeds examined showed a rather high percentage of mortality of their radicle ranging from 0.5% for the Tall Oat grass to 28.3% for the Velvet grass. Now, the Rules for Seed Testing as adopted by the Association of Official Seed Analysts of North America at their meeting held in 1917 at Detroit, provide that "seeds of Gramineae should not be considered as germinated *unless both root and plumule elongate.*" On the strength of this rule all the seeds referred to above having developed a normal plumule but with no sign of a rootlet which is dead within the glumes, would be regarded as not germinated, which in certain cases would very appreciable misrepresent the actual degree of viability.

From Table 1 it will be seen that certain valuable grasses showed a percentage of mortality of their seed-rootlets a good deal higher than the margin of tolerance allowed in the seed laws. It would be advisable to check up the results of germination tests of such grasses as Velvet grass, Meadow Foxtail, Kentucky blue-grass and others, carried out on blotters, by subjecting the seed to a test in the soil. This would be especially advisable in cases where an appreciable number of seeds germinating in a chamber on blotters show the plumule but fail to develop the rootlet.

LIST OF ILLUSTRATIONS.

Figure 33. *Lolium italicum.* Surface view of the epidermal cells in the middle section of the lemma. K, K_1, silicious cells; iK, isolated silicious cell.

Figure 34. *Lolium italicum.* Basal part of the lemma showing epidermal cells in the region where the coleorhiza broke through. Note the initiation of a longitudinal slit along cell *i*.

Figure 35. *Lolium italicum.* A, a layer of sclerenchymatous cells in the middle section of the lemma; B, sclerenchymatous cells at the base of the lemma where the coleorhiza broke through; C, single sclerenchymatous cell; b, b_1, short cells severed from the base of the lemma.

Figure 36. *Festuca arundinacea.* Part of transverse section through the base of the lemma, below the region where the coleorhiza breaks through; ae, outer epidermis; h, prosenchyma; p, parenchyma.

Figure 37. *Festuca arundinacea.* Part of transverse section through the lemma in the region where the coleorhiza breaks through. ae, outer epidermis; h, prosenchyma; p, parenchyma; ie, inner epidermis; g, lateral fibrovascular bundle.

Figure 38. *Festuca arundinacea.* Transversal section through the lemma above the line of rupture, representing the part between the lateral and marginal fibrovascular bundles. ae, outer epidermis; ps, prosenchyma; p, parenchyma; ie, inner epidermis; K, silicious cell.

Figure 39. *Alopecurus pratensis.* Abnormal germination: The radicle pushed the germinating caryopsis out of the sterile and fertile glumes. K, caryopsis; r, radicle; col., coleorhiza; c, coleoptile; pb, plumule; Kl, sterile glumes.

Figure 40. *Holcus lanatus.* Abnormal germination: A, the caryopsis is raised in the sterile glumes with the radicle appearing at their tip. B, the germinating caryopsis, K, after removal of sterile glumes. After normally breaking through the lemma, the radicle, r, grew upward along the sterile glume; c, coleoptile; dk, lemma: vs, palet.

Figure 41. *Hordeum sativum.* Longitudinal section through apical part of the coleorhiza. The upper delicate elliptical cells become thicker toward the apex and terminate by thick-walled cells of the apical appendage.

Figure 42. *Festuca arundinacea.* Surface view of the expanded apical appendage.

Figure 43. Polyembryony in *Poa pratensis.* K, caryopsis; r, r_1, abnormally extending radicles; c, c_1, coleoptiles; p, p_1, plumules; ds, lemma; vs, palet.

Figure 44. Polyembryony in *Arrhenatherum elatius.* K, caryopsis; r, r_1, radicles pushing the seedling out of the glumes; c, c_1, the two equally favored coleoptiles; col, col_1, coleorhizas; sp, fertile glumes.

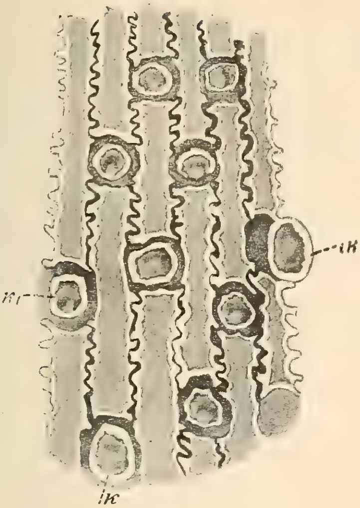

Fig. 33.

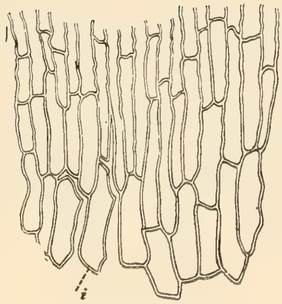

Fig. 34.

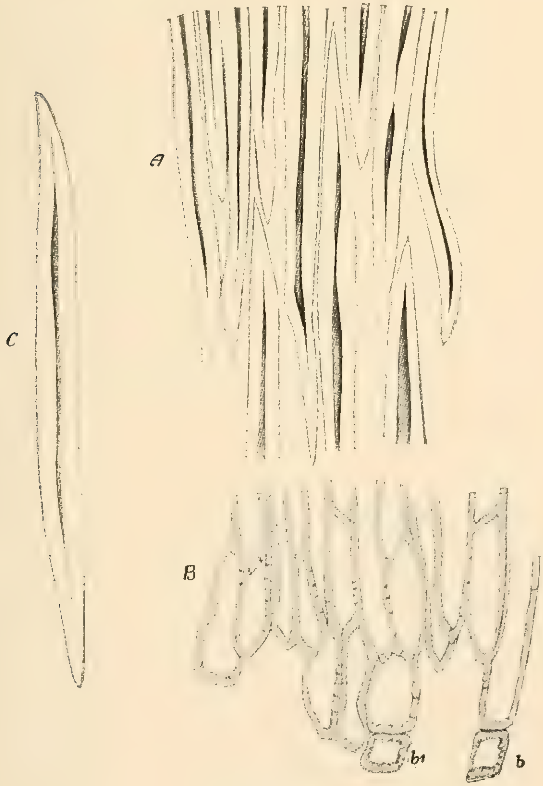

Fig. 35.

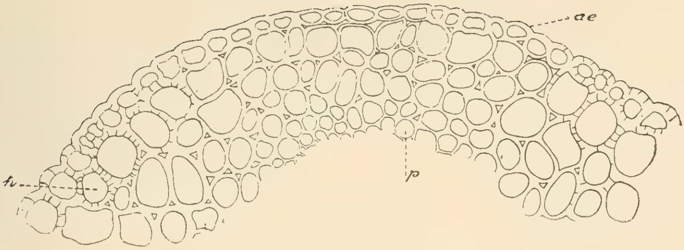

FIG. 36.

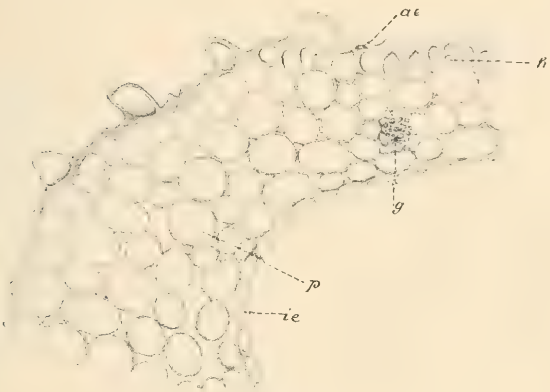

FIG. 37.

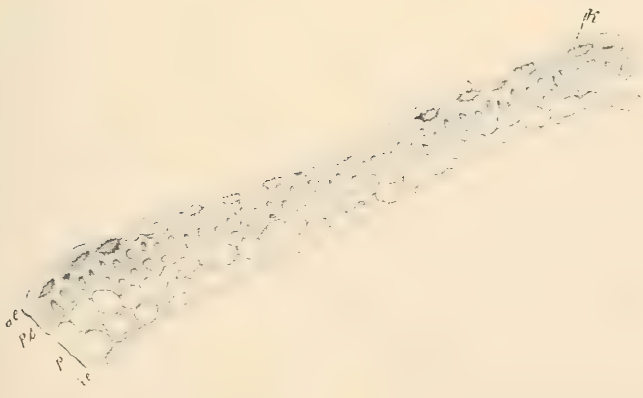

FIG. 38.

Fig. 40.

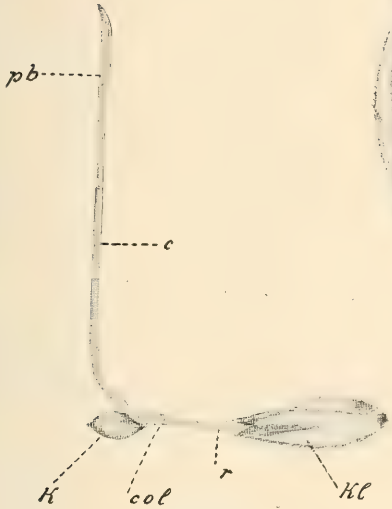

Fig. 39.

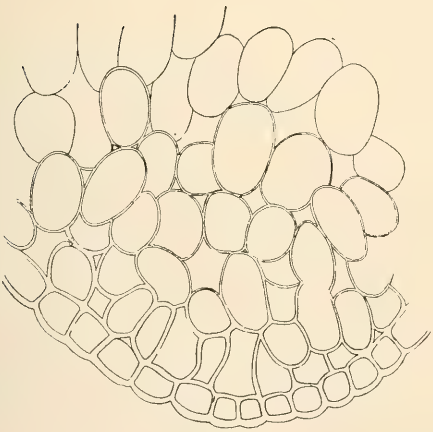

Fig. 41.

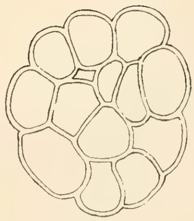

Fig. 42.

FIG. 44.

FIG. 43.

BULLETIN 295

ABSTRACTS OF PAPERS PUBLISHED BY THE STATION IN 1920 BUT NOT INCLUDED IN THE BULLETINS.

A complete list of all the publications issued by and from the Station in 1920 is given on pages x to xi of the introduction to this Report. The following pages contain abstracts of the papers issued during the year that are not included in the Bulletins or Official Inspections for the year.

INHERITANCE IN CROSSES OF DAIRY AND BEEF BREEDS OF CATTLE.

II. On the Transmission of Milk Yield to the First Generation.*

The purpose of this paper is to give briefly the facts discovered on the inheritance of milk yield by the use of the crossbred herd.

If the substance of these pages is recapitulated it is found that Crossbred No. 1 resembles her low producing parent 7.7 times as closely as she does the high producing parent. The other eleven crossbreds resemble the high producing line of milk production from 1.5 to 18.0 times as closely as they do the low line of milk production. If this paralleling of the high line production is averaged it is found that they resemble the high line of production 4.76 times as closely as they do the low line. These facts argue for the transmission of milk production by factors which show partial dominance. It would not seem that they argued for increased vigor of heterosis only, because of the case of Crossbred No. 1, where the low line milk yield was definitely transmitted instead of the high yield. In fact it would appear that this Crossbred is more likely to be a segregate of

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*This is an abstract from a paper by John W. Gowen having the same title and published in the Journal of Heredity, Vol. XI, No. 10.

low milking factors from the high milking factors carried by her dam.

Three levels of milk production are crossed in these experiments. The Aberdeen Angus cattle constitute the lowest level, the Jersey, Guernsey and Ayrshire cattle averaging about the same in milk yield constitute the intermediate level of production and the Holstein-Friesian cattle having the highest yield represent the highest level of production. It is of some interest to compare the results of crossing the different levels. If we omit the result of Crossbred No. 1 it is found that the Holstein-Friesian cows or bulls mated to the second group of cows or bulls (Jersey, Guernsey or Ayrshire) produced offspring who are 8.43 times as near the milk production of the high level on the average as they were the low line of production.

The only cross involving the Holstein-Friesian and Aberdeen Angus, Crossbred No. 44, was 2.2 times as close to the high line of production as she was close to the low line of her parent's milk yield.

It is of interest to note in this connection that Crossbred No. 44's milk yield resembles closely the milk yield of the intermediate group (Jersey, Guernsey and Ayrshire) of these experiments.

The crosses involving the second level of milk production (Jersey, Guernsey and Ayrshire) mated to the third group Aberdeen Angus, had crossbred offspring resembling the high line 7.7 times as closely as they did the low line of production. This figure compares favorably with that of the Holstein-Friesian x Jersey crosses.

If the crosses are compared to determine what effect the high line on the sire's side of the cross may have in comparison with the effect produced by the high line being on the dam's side of the cross it is found that the results in the three lines are contradictory. When the Holstein-Friesian sires were mated to second class dams, Guernseys, the offspring resembled the high line 11.3 times as closely as she did the low line. When the Jersey sire, second class, was mated to the Holstein-Friesian cows, highest class, the milk production of the offspring, once resembled the high class 2.7 to 1 and once the low line 7.7 to 1. The crosses involving the highest milk line, Holstein-Friesian bull, to the lowest milking line Aberdeen Angus cow produced

an offspring resembling the high line 2.2 times as closely as the low line. The crosses of the second level in milk production to the third level show that when the higher level is on the sire's side the daughters resembled the high line 3.6 times as closely as they did the low line. When this higher level is on the dam's side the daughters resembled the high line 9.34 times as closely as they did the low line. It seems doubtful from these results if there are modifying sex linked factors present.

INHERITANCE IN CROSSES OF DAIRY AND BEEF BREEDS OF CATTLE.

III. TRANSMISSION OF BUTTER-FAT PERCENTAGE IN THE FIRST GENERATION.*

This paper presents the facts on the inheritance of butter-fat percentage as discovered by the analysis of the data accumulated in the cross breeding experiment. Twelve crosses were analyzed in this work.

These observations may be regrouped to show the changes brought about in the butter-fat percentage of the offspring in accordance with the way the cross was made. For those crosses in which Holstein-Friesian sire was used the offspring in all cases resembled the low testing sire between 3.3 and 4.5 to 1 as closely as they did the high testing parent, the mean being 3.9 to 1. For those crosses in which the dam was of the Holstein-Friesian breed the results of the offspring were contradictory one approaching the butter-fat percentage of the high test parent 1.4 to 1 and the other approaching the butter-fat test of the low Holstein-Friesian cow 7.3 to 1. The cross involving the Ayrshire dam resembled the low test 2.6 to 1. The high test Guernsey dam when crossed to the lower test Aberdeen Angus sire had a daughter which resembled the low testing sire 5.5 times as closely as she did the high testing dam.

Considering every cross irrespective of their merit for this particular phase of the work the crosses resemble the low testing parental breed 2.23 times as closely as they do the high testing parental breed.

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*This is an abstract from a paper by John W. Gowen having the same title and published in Journal of Heredity, Vol. XI, No. 12.

It is of interest to examine the results of these experiments on butter-fat percentage in the light of those for milk yield. It will be remembered that in the F_1 crossbreds milk yield was intermediate between that of the high and low parents but approached most nearly that of the high parent. In the genetics of many economic characters as yield of grain, size of the animal etc. the explanation used to account for such a phenomena is the heterozygous nature of the factors contained in the F_1 animal as compared to the homozygous nature of the factors in the parental breeds or strains. Without question there may be something to this hypothesis for certain crosses. The results for milk yield and butter-fat percentage do present a paradoxical position when this hypothesis is applied to them. Thus milk yield is increased over what the true intermediate should be. This follows the expectation generally agreed upon and accounted for by heterosis. But on these identically same animals the butter-fat percentage is decreased below the intermediate. This is not the expectation generally considered as due to heterosis although it is by no means impossible to assume that increased vigor may reduce rather than increase a character. The double nature of such a position does not appeal to the author, however, as furnishing more than a verbal explanation of the results having little parallel in the rest of genetics. The explanation which really seems most likely is that we have in these two cases the resultant of partially dominant factors. Numerous similar cases can be cited in genetics literature. Perhaps the best known case is that of *black* in Drosophila where the factor for this is normally classified as a recessive but where if occasion demands it may be used as a dominant; such a factor differs quite distinctly from another like *speck* which is consistently recessive. Such a parallel will explain the inheritance for butter-fat percentage by considering that the factors for low butter-fat percentage display more dominance in their expression than do the factors for high butter-fat percentage.

The inheritance of butter-fat percentage has occupied a prominent place in the discussions of breeding operations by practical dairymen. These men have held the following views as to the mode of this inheritance. The first has claimed that the tendency for high or low butter-fat percentage is transmitted by the sire to his offspring; the second that the dam

transmits the tendency for high or low butter-fat percentage to the offspring; and the third that both parents contribute to the butter-fat percentage transmission. The results of these experiments show that the third of these claims is correct. Such being the case the dairyman who wishes his breeding operations to progress successfully will find it desirable to examine both sides of his animals' pedigrees carefully. Thus, today, the Jersey breeder pays a good deal more attention to the sires' side of the pedigree than he does the dams' side of the pedigree when in truth both sides are equally important.

MODE OF TRANSMISSION OF MILK QUANTITY AS SHOWN BY FIRST GENERATION CROSSES OF DAIRY AND BEEF BREEDS OF CATTLE.*

This paper is a further discussion of the results indicated in the abstracts on Inheritance of Milk Yield.

THE LIFE CYCLE OF APHIDS AND COCCIDS.*

To attempt to epitomize the life cycle of the aphid is like trying to draw an orderly sketch of Chaos. But after all, the confusion may be more seeming than real and certain rules, beset though they may be with exceptions, govern the life of even the aphid.

The gamogenetic egg is an outstanding argument for the conclusion that the aphid of the North is holding more closely to its prehistoric past than are those that spend their lives where the successive seasons of the year offer a constant source of food. For in the region of real winters there is no member of the family Aphididae (in its restricted sense) whose total life history has been worked out, that is known to pass its annual cycle without exhibiting a concluding generation comprising both sexes. The aphid, then, starts its life cycle like a typical insect—in the fertilized egg.

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*This is an abstract from a paper by John W. Gowen having the same title and published in Proceedings Soc. Promotion Agricultural Research.

*This is an abstract from a paper, having the same title, written by Edith M. Patch and published in Annals of the Entomological Society of America, Volume XIII, No. 2, pp. 156-167.

The overwintering egg is thus true to the traditions of the Hexapods, but with it ends all conventional observances, for between one such egg and the next in sequence there are crowded such phenomena as a succession of parthenogenetic viviparous generations; extreme examples of polymorphism; alternation of generations in a series where a duplication may not occur for seven or more generations; parallel series in which certain females give birth to true sexes without beaks while others of the same generation give rise to normal young which hibernate in the first instar without feeding; and a system of seasonal migration which is not surpassed by any other in the animal kingdom. That all these divergences from the ordinary life cycle for insects take place within the limits of the family Aphididae would seem remarkable indeed; but it is no less than appalling to realize that the total range of phenomena just indicated may be exhibited by a single species.

The eccentricities of the coccids are concerned with the specialization of their structural characters, and the modified metamorphosis of both sexes rather than with any striking range of habit or peculiarity in sequence of generations; since their typical life cycle comprises between one fertilized egg stage and the next but a single generation composed of both sexes. The extreme possibilities of coccid metamorphosis are illustrated by those species in which the females, at their first molt, lose, for good and all, eyes, antennae and legs. exhibiting in this atrophy of those organs of orientation and locomotion, a transformation which has to do with the loss of such organs as characterized them as insects in the first instar, rather than in the acquisition and development of the structures of an adult hexapod. This metamorphosis by reduction, associated with the complete absence of wing development in the female is correlated with the sedentary habit of this family and is in line with the atrophy of class structures in parasitic animals. But the suppression of generalized characters does not inhibit the appearance of special structures of a high degree of development, as is beautifully illustrated by the wax glands, marvelous in form and variety, to be found in the coccids; a concentration of structural effort directed toward the secretion of a waxy protection for these sedentary creatures and their eggs.

TRANSMISSION OF THE MOSAIC DISEASE OF IRISH POTATOES.*

This paper summarizes results of the continuation of experiments which were concerned with certain phases of potato mosaic, in particular transmission, and which were conducted mostly in northeastern Maine.

Transmission from season to season occurs in tubers produced by diseased plants. The parent plants may appear healthy throughout the season if infected late. Their diseased progeny show symptoms varying greatly in severity but averaging about the same for different lots and varieties. The severity of symptoms shown by obviously diseased parent plants is not changed much in their progeny. The percentage of disease in the progeny of apparently healthy parents can be reduced by selection of hills, tubers, or seed-pieces, but the reduction is too slight and uncertain to be of value.

The infectiousness of the disease was demonstrated by effecting transmission by means of tuber grafts, stem grafts, and inoculation with juice. This was done in part in the field with plant-lice eliminated, because previously reported experiments upon infectiousness had not been performed under such conditions and because plant-lice had been shown to be carriers of the disease. Juice inoculation was attempted from one variety to another and was successful.

Plant-lice, as had been found and reported previously, were a reliable means for transferring the disease. As more conditions favored the dispersal of these insects from diseased plots to healthy plants, there followed greater spread of the disease. One such favorable condition was growth in the open field in contrast to growth under insect cages in the field and in contrast to growth in a greenhouse with plant-lice controlled. Other favorable conditions were greater proximity to diseased plots, greater interseasonal abundance of plant-lice, and later dates of harvesting together with seasonal increase of plant-lice.

*This is an abstract of a paper by Donald Folsom and a cooperating member of the Bureau of Plant Industry, having the same title and published in Journal of Agricultural Research, Vol. XIX, No. 7, p. 315-337.

Tests were made regarding the possibility of the existence of various means of transmission other than plant-lice. These tests indicated that among the various conceivable means of transmission plant-lice are distinguished from others by at least a much greater effectiveness and probably by being the only effective ones. The other means tested with negative results were soil, flea beetles, Colorado potato beetles, the seed-cutting knife, and contact of roots, stems, leaves, and seed-pieces.

It appears that the most important measures to be taken to prevent the spread of mosaic in a susceptible variety are those which will reduce or prevent dispersal of plant-lice from diseased to healthy plants.

METEOROLOGICAL OBSERVATIONS.

For many years the meteorological apparatus was located in the Experiment Station building and the observations were made by members of the Station Staff. June 1, 1911, the meteorological apparatus was removed to Wingate Hall and the observations are in charge of Dr. James S. Stevens, professor of physics in the University of Maine.

In September, 1914, the meteorological apparatus was moved to Aubert Hall, the present headquarters of the physics department.

The instruments used are at Lat. 44° 54′ 2″ N. Lon. 64° 40′ 5″ W. Elevation 135 feet.

The instruments used are the same as those used in preceding years, and include: Maximum and minimum thermometers; rain gauge; self-recording anemometer; vane; and barometers. The observations at Orono now form an almost unbroken record of fifty-two years.

1920	January	February	March	April	May	June	July	August	September	October	November	December	Average	Total
Highest temperature	34	41	69	69	84	88	88	92	87	72	54	43		
Lowest temperature	—26	—29	— 9	21	5	39	44	44	30	28	2	— 9		
Mean temperature	10.81	17.35	31.45	39.6	50.6	61.6	66.3	66.95	54.1	50.1	30.65	23.05	41.88	
Mean temperature in 52 years	16.02	14.83	30.22	40.03	51.26	60.86	66.0	66.05	59.52	50.62	37.88	24.05	43.11	
Total precipitation in inches	2.55	7.75	2.92	4.48	1.53	2.16	3.36	2.19	5.71	2.37	2.68	2.81		40.51
Mean precipitation in 52 years	2.56	3.50	3.95	2.94	3.50	3.40	3.49	2.30	3.42	3.80	3.40	3.46		39.73
Number of days with precipitation of .01 or more	7	12	10	9	3	9	10	7	12	7	10	9		105
Snowfall in inches	25.5	77.5	13.5	.5							10.25	15.5		142.75
Mean snowfall in 52 years	21.8	22.3	14.88	5.78	.225					.725	6.94	16.46		
Number of clear days	17	15	19	10	17	15	15	20	14	16	9	9		176
Number of fair days	9	4	3	13	13	13	14	9	10	9	12	11		120
Number of cloudy days	5	10	9	7	1	2	2	2	6	6	9	11		70
Total movement of wind in miles	3041	3738	4973	4991	3572	3411	3447	2641	3200	3564	3606	3922		44106

REPORT OF THE TREASURER.

The Station is a department of the University and its accounts are kept in the office of the Treasurer of the University. The books, voucher files, etc., are, however, all distinct from those of the other departments of the University. The classification of accounts is that prescribed by the auditors on the part of the Federal Government, and approved by the State Auditor. All of the accounts are audited by the State Auditor, and the Hatch Fund and Adams Fund accounts are also audited by the Office of Experiment Stations acting for the United States Secretary of Agriculture in accordance with Federal Law.

The income of the Station from public sources for the year that ended June 30, 1920, was:

U. S. Government, Hatch Fund appropriation	$15,000.00
U. S. Government, Adams Fund appropriation	15,000.00
State of Maine, Animal Husbandry investigation appropriation	5,000.00
State of Maine, Aroostook Farm investigation	5,000.00
State of Maine, Highmoor Farm investigations	5,000.00

The cost of maintaining the laboratories for the inspection analyses is borne by analysis fees and by the State Department of Agriculture. The income from sales at the experiment farms is used for the expense of investigations. The printing is paid for by an appropriation to the University.

At Aroostook Farm there are in connection with the cooperative work with the Federal Department of Agriculture expenditures mostly under "labor" for the Department and for which the Station is reimbursed. There are also certain expenditures for the Department made from sales of crops from Department investigations that do not appear in the tabular statements. They are carried as distinct and separate accounts, always with credit balances, on the Station ledger.

REPORT OF THE TREASURER FOR YEAR ENDING JUNE 30, 1920.

DISBURSEMENTS.

	Hatch Fund	Adams Fund	Animal Husbandry Investigations
Salaries	$8068.25	$9999.96	$4498.20
Labor	1042.75	2032.67	--------
Publications	195.04	--------	--------
Postage and Stationery	608.96	61.25	167.37
Freight and Express	148.11	116.28	12.00
Heat, light and power	598.29	289.18	--------
Chemical and laboratory supplies	4.12	23.58	49.46
Seeds, plants and sundry supplies	705.87	223.44	20.51
Fertilizers	830.89	--------	--------
Feeding stuffs	1912.09	1628.99	--------
Library	40.27	136.65	--------
Tools, machinery and appliances	125.87	--------	--------
Furniture and fixtures	204.82	121.75	--------
Scientific apparatus and specimens	46.19	26.96	.68
Live stock	--------	--------	--------
Traveling expenses	339.62	275.81	--------
Contingent expenses	--------	--------	251.78
Buildings	128.86	63.48	--------
Total	15000.00	15000.00	5000.00

REPORT OF THE TREASURER FOR YEAR ENDING JUNE 30, 1920.

DISBURSEMENTS.

	Aroostook Farm	Highmoor Farm	General Account	Inspection Analysis
Salaries	$1220.00	$1080.00	$1676.35	$11026.43
Labor	4915.23	2197.70	1888.06	--------
Publications	--------	--------	--------	--------
Postage and Stationery	71.05	73.95	78.83	385.07
Freight and Express	36.20	29.82	216.05	138.07
Heat, light and power	258.63	381.48	201.15	590.02
Chemical and laboratory supplies	--------	--------	--------	457.43
Seeds, plants and sundry supplies	1063.65	357.83	1761.96	39.71
Fertilizers	875.15	43.50	--------	--------
Feeding stuffs	1220.11	180.58	724.88	--------
Library	--------	--------	--------	--------
Tools, machinery and appliances	396.14	408.50	2186.07	--------
Furinture and fixtures	18.30	--------	--------	78.58
Scientific apparatus and specimens	--------	--------	25.25	183.92
Live stock	90.00	52.00	2300.00	--------
Traveling expenses	16.44	10.12	186.94	386.87
Contingent expenses	66.50	25.85	174.56	86.94
Buildings	214.71	158.67	--------	26.14
Total	$10,462.11	$5000.00	$11,420.10	$13,399.15

INDEX

INDEX TO REPORTS FOR THE YEARS 1916 TO 1920, AND TO BULLETINS 246 TO 295 INCLUSIVE.

In each reference the first two figures indicate the year. Thus, '20, 207, indicates page 207 of the report for 1920.

APPENDIX

Official Inspections

95-98

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April, 1920

MAINE
AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE.
CHAS. D. WOODS, Director

ANALYSTS.

James M. Bartlett
Roydon L. Hammond
Elmer R. Tobey
C. Harry White

Official Inspections

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DRUGS AND FOODS

CHAS. D. WOODS.

The Commissioner of Agriculture is the executive of the law regulating the sale of drugs and foods in Maine. It is the duty of the Director of the Maine Agricultural Experiment Station to make the analyses of the samples collected by the Commissioner, and to publish the results of the analyses together with the names of the persons from whom the samples were obtained, and such additional information as may seem advisable.

NOTE. All correspondence relative to the inspection laws should be addressed to the Bureau of Inspections, Department of Agriculture, Augusta, Maine.

ANALYSES OF DRUGS AND FOODS

In the following pages are given the reports of analyses of the samples of drugs and foods sent to the Station for examination by the Comissioner of Agriculture in the calendar year 1919.

In reporting samples of drugs a margin of 10 per cent in either direction is allowed as coming within the limits of error. For instance, a sample of spirit of camphor that is from 90 to 110 per cent of standard would be passed. In the case of a sample between 85 to 89 per cent or 106 to 110 per cent of standard the druggist is cautioned. Larger variations result in hearings, and usually in prosecutions.

SPIRIT OF CAMPHOR.

Table showing the results of analyses of samples of spirit of camphor purchased in 1919. A properly prepared spirit of camphor carries 10 per cent gum camphor and 86 per cent by volume of alcohol. In the following table if a sample is within 5 per cent of standard it is reported "In accord with standard." If it varies more than 5 and less than 10 per cent from the standard it is reported "Slightly above (or below) standard strength." If greater variation the percentage is given. The samples are arranged alphabetically by towns and dealers.

Station number.	TOWN AND DEALER.	Results of Examination as Regards Gum Camphor.
19431	Auburn. H. W. Getchell	In accord with standard.
19433	Auburn. Claude E. Packard	In accord with standard.
19435	Auburn. Jos. A. Phenix	In accord with standard.
19572	Biddeford. L. Doyon & Co.	Four tenths of one per cent of standard strength. Not camphor at all but apparently put up for booze. Adulterated.
19574	Biddeford. Morin Drug Co.	Slightly below standard strength.
19460	Brunswick. P. J. Meserve	Dangerously above standard strength.
19561	Cumberland Mills. L. K. Paine	Eighty-nine per cent of standard strength. Adulterated.
19071	Fairfield. Fred H. Neal	In accord with standard.

SPIRIT OF CAMPHOR—Concluded.

Station number.	TOWN AND RETAIL DEALER.	Results of Examination as Regards Gum Camphor.
19483	Fairfield. Fred H. Neal	In accord with standard.
19564	Freeport. Geo. A. Wilbur	In accord with standard.
19511	Gardiner. Theo. N. Shorey	In accord with standard.
19557	Gorham. Edgar F. Carswell	In accord with standard.
19446	Lewiston. H. R. Alden	In accord with standard.
19441	Lewiston. Arthur Dussault	In accord with standard.
19449	Lewiston. W. H. Teague	Dangerously above standard strength.
19456	Lisbon Falls. A. N. Beal	Dangerously above standard strength.
19453	Livermore Falls. E. P. Smart	Slightly above standard strength.
19474	No. Anson. Frank H. Holley	In accord with standard.
19471	Oakland. S. J. Foster	In accord with standard.
19580	Oxford. Geo. H. Jones	In accord with standard.
19524	Portland. Frank J. Bragdon	In accord with standard.
19535	Portland. John H. Hamel	Seventy-seven per cent of standard strength. Adulterated.
19516	Portland. Theara Hilton	Dangerously above standard strength.
19523	Portland. Otis Drug Co	In accord with standard.
19520	Portland. Park Drug Store Inc	In accord with standard.
19542	Portland. People's Pharmacy	In accord with standard.
19506	Randolph. Ralph L. Booker	In accord with standard.
19468	Richmond. Louis A. Gaubert	In accord with standard.
19440	Sabattus. Chas. W. Coombs	In accord with standard.
19569	Saco. Earl C. Wakefield	In accord with standard.
19480	Skowhegan. G. R. Fogg	Slightly above standard strength.
19478	Skowhegan. Fuller Drug Store	In accord with standard.
19479	Skowhegan. Sampson & Avore	Slightly above standard strength.
19472	Solon. L. W. McIntire	In accord with standard.
19484	Waterville. College Avenue Pharmacy	In accord with standard.
19487	Waterville. Davian & Cunion	In accord with standard.
19488	Waterville. J. H. DeOrsay	In accord with standard.
19489	Waterville. H. H. Dunbar	In accord with standard.
19485	Waterville. Larkin Drug Co	In accord with standard.
19491	Waterville. Arthur J. Loubier	More than twice the standard strength. Adulterated.
19486	Waterville. Waterville Drug Store	Slightly above the standard strength.
19560	Westbrook. Raymond & Marr	Sixty-five per cent of standard strength. Adulterated.

SPIRIT OF CHECKERBERRY.

Table showing the results of analyses of samples of spirit of checkerberry (Wintergreen) purchased in 1919. This is not now an U. S. P. preparation. Formerly it was, and carried 5 per cent oil of wintergreen. In the following table if a sample is within 5 per cent of standard it is reported "in accord with standard." If it varies more than 5 and less than 10 per cent from the standard it is reported "slightly above (or below) standard strength." If greater variation the percentage is given. Samples arranged alphabetically by towns and dealers.

Station number.	TOWN AND DEALER.	Results of Examination as Regards Oil of Wintergreen.
18982	Auburn. Claude E. Packard	In accord with standard.
19036	Bangor. Chas. H. Davis	In accord with standard.
19049	Bangor. Frawley's Pharmacy	Two hundred and six per cent of standard strength. Dangerously high.
19041	Bangor. L. K. Liggett Co	Slightly above standard strength.
19039	Bangor. H. K. Priest	Slightly below standard strength.
18962	Bath. D. T. Dougherty	In accord with standard.
18941	Biddeford. Geo. W. Traynor	In accord with standard.
18965	Brunswick. George Drapeau	In accord with standard.
19044	Ellsworth. C. E. Alexander	In accord with standard.
19074	Fairfield. Fred H. Neal	In accord with standard.
18974	Lewiston. P. W. Babcock	One hundred twenty-four per cent of standard strength. Dangerously high.
18971	Lewiston. R. W. Clark Est	In accord with standard.
18978	Lewiston. Pharmacie Nationale	In accord with standard.
18975	Lewiston. Wakefield Bros	One hundred twenty-six per cent of standard strength. Dangerously high.
18998	Livermore Falls. J. C. Ham	In accord with standard.
19020	Old Town. Burnham Drug Co	One hundred and forty-two per cent of standard strength. Dangerously high.
18895	Portland. Edward L. Foss	In accord with standard.
18906	Portland. Franklin Drug Co	In accord with standard.
18890	Portland. Heseltine & Tuttle Co	In accord with standard.
18915	Portland. John D. Keefe	One hundred and twenty-eight per cent of standard strength. Dangerously high.
18910	Portland. W. P. Keenan	In accord with standard.

SPIRIT OF CHECKERBERRY—Concluded.

Station number.	TOWN AND DEALER.	Results of Examination as Regards Oil of Wintergreen.
18898	Portland. Lewis K. Liggett Co.	In accord with standard.
18885	Portland. Geo. W. Rankin	Seventy-three per cent of standard strength. Adulterated.
18920	Portland. H. L. Stimson	Sixty-four per cent of standard strength. Adulterated.
18902	Portland. Dudley Weed Co.	One hundred and forty per cent of standard strength. Dangerously high.
18951	Rockland. W. A. Johnston	One hundred and twenty-eight per cent of standard strength. Dangerously high.
18950	Rockland. C. W. Sheldon	Two hundred and thirty-four per cent of standard strength. Dangerously high.
19002	Rumford. Waldo St. Pharmacy	Branded as an extract. Is in accord with standard for spirit of Wintergreen.
18936	Saco. Edward Goshen	Branded as an extract. Is in accord with standard for extract.
18939	Saco. Earl C. Wakefield	In accord with standard.
18934	Westbrook. Raymond & Marr	Branded as an extract. Is slightly below standard for spirit of wintergreen.
18924	Woodfords. F. L. Winship	In accord with standard.
19563	Woodfords. John M. Stevens	An extract and not an essence. Misbranded. In accord with standard for extract.

EXTRACT OF PEPPERMINT.

Table showing results of analyses of samples of extract of peppermint delivered to inspector when he called for spirits of peppermint. They were, however, properly labelled. An extract of peppermint used as a food flavor should contain 3 per cent oil of peppermint.

Station number.	TOWN, DEALER AND BRAND.	Results of Examination as Regards Oil of Peppermint.
19054	Bath. William A. Armstrong. "Kimball's Green Mountain Brand."	In accord with standard.
18905	Portland. Pearl St. Drug Store. "Extract of Peppermint."	In accord with standard.
18937	Saco. J. E. Beckwith. "Baker's Extract of Peppermint."	In accord with standard.
18923	Woodfords. John M. Stevens. "Extract of Peppermint."	In accord with standard for extract. Carries dosage on the label and is therefore misbranded.

SPIRIT OF PEPPERMINT.

Table showing results of analyses of samples of spirit of peppermint purchased in 1919. A properly prepared spirit of peppermint, sometimes called essence of peppermint, carries 10 per cent oil of peppermint and 85 per cent by volume of alcohol. In the following table if a sample is within 5 per cent of standard it is reported "In accord with standard." If it varies more than 5 and less than 10 per cent from the standard it is reported "slightly above (or below) standard strength." If greater variation the percentage is given. Samples arranged alphabetically by towns and dealers.

Station number.	TOWN AND DEALER.	Results of Examination as Regards Oil of Peppermint.
18983	Auburn. H. W. Getchell	Eighty-two per cent of standard strength. Adulterated.
18981	Auburn. O. W. Jones	Thirty-four per cent of standard strength. Adulterated.
19033	Bangor. Chas. M. Brown	Slightly below standard strength.
19038	Bangor. Buckley Drug Co.	Dangerously above standard strength.
19047	Bangor. B. H. Burke	In accord with standard.
19050	Bangor. Caldwell Sweet Co.	In accord with standard.
19035	Bangor. Essex Pharmacy	Slightly below standard strength.
18958	Bath. Webber's Drug Store	In accord with standard.
18960	Bath. L. E. Wilson	Slightly below standard strength.
18943	Biddeford. N. P. Baillaigeon	In accord with standard.
18942	Biddeford. Boynton's Pharmacy	In accord with standard.
18945	Biddeford. Morin Drug Co.	Slightly below standard strength.
19025	Brewer. V. H. Hinckley	Eighty-four per cent of standard strength. Adulterated.
19026	Brewer. R. W. Merrill	In accord with standard.
18964	Brunswick. P. J. Meserve	Eighty-eight per cent of standard strength. Adulterated.
19028	Bucksport. A. F. Page	In accord with standard.
18931	Cumberland Mills. Kirkwood & Welch	In accord with standard.
19562	Cumberland Mills. Kirkwood & Welch	In accord with standard.
18996	Farmington. Hardy's Pharmacy	Somewhat above standard strength.
18977	Lewiston. E. S. Baribault	In accord with standard.
18976	Lewiston. Arthur Dussault	Dangerously above standard strength.
18973	Lewiston. L. K. Liggett Co.	In accord with standard.
18969	Lewiston. W. E. Riker	In accord with standard.

SPIRIT OF PEPPERMINT—Concluded.

Station number.	TOWN AND DEALER.	Results of Examination as Regards Oil of Peppermint.
18997	Livermore Falls. E. P. Smart	Dangerously above standard strength.
19018	Old Town. Alexander Fraser	In accord with standard.
19023	Orono. Chas. F. Nichols	Sixty per cent of standard strength. Adulterated.
18909	Portland. S. Belli	Slightly below standard strength.
18893	Portland. Bramhall Square Pharmacy	Forty per cent of standard strength. Adulterated.
19594	Portland. Bramhall Square Pharmacy	Eighty-six per cent of standard strength. Adulterated.
18892	Portland. Coombs Drug Co	Slightly below standard strength.
18900	Portland. C. H. Guppy Co., Inc	In accord with standard.
18891	Portland. Hurlburt Brothers	Slightly below standard strength.
18913	Portland. Myrtle Pharmacy	In accord with standard.
18889	Portland. Park Drug Store	Slightly below standard strength.
18907	Portland. People's Pharmacy	Eighty per cent of standard strength. Adulterated.
18887	Portland. Frank H. Power	In accord with standard.
18953	Rockland. Corner Drug Store, Inc	In accord with standard.
18949	Rockland. C. H. Moor & Co	In accord with standard.
18954	Rockland. Pendleton Pharmacy	In accord with standard.
18999	Rumford. Rumford Drug Co	Forty-four per cent of standard strength. Adulterated.
19001	Rumford Falls. C. E. Fernald	In accord with standard.
18929	So. Portland. Walter Dow	In accord with standard.
18933	Westbrook. T. R. Pye	Fourteen per cent of standard strength. Adulterated.
18922	Woodfords. Chapman & Wyman	In accord with standard.
18925	Woodfords. Deering Drug Co	In accord with standard.
18928	Woodfords. Gamage Pharmacy	In accord with standard.

SOLUTION OF MAGNESIUM CITRATE.

Table showing the results of analyses of samples of solution of magnesium citrate purchased in 1920. A solution of magnesium citrate should carry 1.5 grams of magnesium oxide per 100 milliter. In the table if the sample carried not less than 1.4 or more than 1.6 it is reported in accord with standard. If it carries between 1.35 and 1.40 or 1.60 and 1.65 grams it is reported as slightly below (or above) standard. If it carries less than 1.35 or more than 1.65 it is reported much below (or above) standard and adulterated. Samples arranged alphabetically by towns.

Station number.	TOWN AND DEALER.	Results of Examination as Regards Magnesium Oxide.
19448	Lewiston. L. K. Liggett Co.	Much above standard strength. Adulterated.
19438	Lewiston. Charles Martel	Much below standard strength. Adulterated.
19443	Lewiston. Warren E. Riker	Slightly below standard strength.
19476	Madison. E. W. Wright	Much below standard strength. Adulterated.
19544	Portland. Colcord & Washburn	Much below standard strength. Adulterated.
19533	Portland. Cumberland Avenue Pharmacy	Much above standard strength. Adulterated.
19526	Portland. Sumner C. Davis, Jr.	Much below standard strength. Adulterated.
19525	Portland. Edward L. Foss	In accord with standard.
19546	Portland. John J. Gill	Much below standard strength. Adulterated.
19529	Portland. C. H. Guppy Co.	Much below standard strength. Adulterated.
19540	Portland. H. H. Hays Sons	In accord with standard.
19531	Portland. F. J. Holland	Much below standard strength. Adulterated.
19521	Portland. Hurlburt Brothers	In accord with standard.
19547	Portland. W. P. Keenan	Much below standard strength. Adulterated.
19527	Portland. L. K. Liggett Co.	Much below standard strength. Adulterated.
19545	Portland. Frank D. McCarty	In accord with standard.
19515	Portland. Geo. W. Rankin	Much above standard strength. Adulterated.
19538	Portland. H. L. Stimson	Much below standard strength. Adulterated.
19551	Woodfords. Chapman & Wyman	Much above standard strength. Adulterated.
19556	Woodfords. S. B. Gamage	Much above standard strength. Adulterated.
19553	Woodfords. Frank L. Winship	Much below standard strength. Adulterated.

HYDROCHLORIC ACID.

Table showing the results of examination of samples of hydrochloric acid purchased in 1920. Properly prepared U. S. P. hydrochloric acid carries 10 per cent of the acid. The samples are arranged alphabetically by towns.

Station number.	TOWN AND DEALER.	Results of Examination.
19187	Bath. Leonard & Mitchell	Eighty-nine per cent of standard strength. Adulterated.
19573	Biddeford. Boynton's Pharmacy	In accord with standard.
19576	Biddeford. Leo E. Jones	In accord with standard.
19575	Biddeford. J. W. Mahoney	Seventy-four per cent of standard strength. Adulterated.
19577	Biddeford. John H. Seidel	In accord with standard.
19461	Brunswick. H. W. & E. B. Allen	In accord with standard.
19458	Brunswick. George Drapeau	In accord with standard.
19459	Brunswick. Wilson's Pharmacy	In accord with standard.
19588	Dixfield. Guy O. Gardner	In accord with standard.
19509	Gardiner. Chas. H. Bean	In accord with standard.
19507	Gardiner. Jackson's Drug Store	In accord with standard.
19439	Lewiston. Globe Drug Store	In accord with standard.
19444	Lewiston. Wakefield Bros	In accord with standard.
19455	Livermore Falls. J. C. Ham	In accord with standard.
19583	Norway. Frank P. Stone	In accord with standard.
19541	Portland. S. Belli	In accord with standard.
19522	Portland. Coombs Drug Co	Dangerously above standard strength.
19536	Portland. Wm. J. Flannigan	Somewhat above standard strength.
19519	Portland. H. G. Hansen	In accord with standard.
19528	Portland. Heseltine & Tuttle Co	Dangerously above standard strength.
19518	Portland. E. C. McDonough	Eighty-six per cent of standard strength. Adulterated.
19539	Portland. Geo. W. Merrill	In accord with standard.
19548	Portland. James H. Murren	In accord with standard.
19534	Portland. Myrtle Pharmacy	Eighty-six per cent of standard strength. Adulterated.
19532	Portland. John M. Shaw	In accord with standard.
19530	Portland. Smith & Bore	In accord with standard.
19543	Portland. Chas. E. Wheeler	In accord with standard.
19467	Richmond. W. A. Bibber	In accord with standard.
19590	Rumford. Bowers & Vallee Co	Somewhat above standard strength.
19591	Rumford. Fernald's Pharmacy	In accord with standard.
19589	Rumford. Rumford Drug Co	Slightly above standard strength.

HYDROCHLORIC ACID—Concluded.

Station number.	TOWN AND DEALER.	Results of Examination.
19592	Rumford. Waldo Street Pharmacy	In accord with standard.
19567	Saco. E. J. Bradbury	Slightly above standard strength.
19570	Saco. C. H. Sawyer	In accord with standard.
19584	So. Paris. Chas. H. Howard	Dangerously above standard strength.
19585	So. Paris. A. French Stevens	In accord with standard.
19550	So. Portland. Walter Dow	Somewhat above standard strength.
19490	Waterville. Willard R. Jones	In accord with standard.
19492	Waterville. L. K. Liggett Co.	In accord with standard.
19558	Westbrook. Thomas R. Pye	In accord with standard.
19559	Westbrook. Chas. A. Vallee	Eighty per cent of standard strength. Adulterated.
19579	West Paris. S. T. White	Seventy-four per cent of standard strength. Adulterated.
19555	Woodfords. W. A. Oxnard	In accord with standard.
19554	Woodfords. James M. Scanlan	Dangerously above standard strength.
19552	Woodfords. John M. Stevens	In accord with standard.
19566	Yarmouth. W. H. Rowe	In accord with standard.
19565	Yarmouthville. Cooks Drug Store	Eighty-one per cent of standard strength. Adulterated.

ZINC OINTMENT.

Table showing the results of analyses of samples of zinc ointment purchased in 1919. Properly prepared zinc ointment will carry 20 per cent of zinc oxide. As will be noted there was considerably variation from the U. S. P. standard All samples were passed.

Station number.	TOWN AND NAME OF DRUGGIST	Weight		Zinc oxide found per cent
		Purchased ounce	Obtained ounce	
19434	Auburn. Perryville Drug Store	2	1.98	23.63
19513	Hallowell. Wm. T. Quinn	4	4.02	21.17
19445	Lewiston. P. W. Babcock	4	3.86	21.40
19475	Madison. H. H. Haines	4	5.29	18.31
19452	Mechanic Falls. Merrill & Denning	4	3.99	20.76
19582	Norway. Frank Kimball	4	3.85	18.20
19517	Portland. Frank H. Power	4	3.99	18.92
19571	Saco. Edward Goshen	2	2.08	21.19

LIME WATER.

One sample of lime water was collected from Geo. W. Harvey, 416 Cumberland Avenue, Portland and was found to be in accord with the standard and passed.

SWEET SPIRITS OF NITRE.

Two samples of sweet spirits of nitre were examined which were slightly below the proper strength. One of these was from Leonard & Mitchell, 194 Front Street, Bath, and the other from Fred H. Neal, Fairfield.

TINCTURE OF IODINE.

Two samples of tincture of iodine were obtained, one from Fred H. Neal, Maine Street, Fairfield, was found to be in accord with standard and passed. A sample from Leonard & Mitchell which they claimed to have purchased from McKesson & Robbins, New York, was somewhat low in iodine but within the limit of potassium iodine. It was recommended to pass the sample but caution the dealer.

TINCTURE OF DIGITALIS, TINCTURE OF NUX VOMICA, TINCTURE OF OPIUM.

The inspector collected and sent to the Station several samples of the above preparations. Although a pharmacist he had not the knowledge of the methods of assay of such materials and the samples he purchased were too small to permit of the alkaloidal survey. Therefore these important and rather dangerous remedial agents could be examined only superficially and not for their medicinal strength.

WITCH HAZEL. HAMAMELIS WATER.

According to the U. S. P. this is a preparation made by distillation. In practice it is not distilled but is an extract. Its medicinal properties are negligible. It was introduced into the U. S. P. because of the "universally recognized need in American families for an embrocation which appeals to the psychic influence of faith." The two samples collected were in approximate accord with the requirements.

ICE CREAM.

Table showing the results of the examination of samples of ice cream collected in the season of 1919, arranged alphabetically by towns. A lawful ice cream carries not less than 14 per cent milk fat. A fruit cream carries not less than 12 per cent milk fat.

Station number.	TOWN AND DEALER.	Results of Examination*
19268	Auburn. Mellen T. Downing	Well above standard.
19267	Auburn. Fred L. Ruggles	Lawful.
19269	Auburn. Winslow-Scannell	Low.
19196	Augusta. B. E. Bither	Well above standard.
19215	Augusta. N. T. Folsom Son & Co.	Slightly below standard.
19216	Augusta. Robert Miller	Well above standard.
19218	Augusta. G. & M. Pepin	Well above standard.
19195	Augusta. Harry Slosburg	Slightly below standard.
19217	Augusta. Arthur Tetreault	Low.
19197	Augusta. E. L. Winslow	Low.
19179	Bangor. The Apollo	Well above standard.
19224	Bangor. Bangor Candy Kitchen	Well above standard.
19225	Bangor. George F. Floros	Well above standard.
19178	Bangor. N. T. Floras	Low.
19177	Bangor. Kontos & Boretos	Well above standard.
19223	Bangor. Palace of Sweets Co.	Well above standard.
19226	Bangor. Riker Jaynes	Low.
19176	Bar Harbor. Bar Harbor Tea Room	Well above standard.
19171	Bar Harbor. George M. Cleaves	Well above standard.
19172	Bar Harbor. W. B. Marshall	Lawful.
19174	Bar Harbor. Tullio Boier	Well above standard.
19173	Bar Harbor. Charles A. Venchey	Well above standard.
19175	Bar Harbor. West End Drug Store	Slightly below standard.
19262	Bath. F. H. Allen	Slightly below standard.
19300	Bath. F. H. Allen	Well above standard.
19258	Bath. Octave Breten	Lawful.

*Explanation of terms. Lawful, just above standard. Well above standard, at least 1 per cent above. Slightly below, not more than 1 per cent below standard. Low, more than 1 per cent below standard.

ICE CREAM—Continued.

Station number.	TOWN AND DEALER.	Results of Examination*
19344	Bath. Octave Breten	Well above standard.
19261	Bath. A. Hallett & Co	Low.
19260	Bath. Leonard & Mitchell	Well above standard.
19259	Bath. Spear Folks	Slightly below standard.
19263	Bath. John Stargolas	Slightly below standard.
19193	Belfast. Roscoe Arey	Well above standard.
19192	Belfast. Coombs Bros	Lawful.
19194	Belfast. Reed & Hills	Lawful.
19338	Biddeford. James Christenson	Low.
19339	Biddeford. Daniel Griney	Low.
19336	Biddeford. Mahoney Pharmacy	Slightly below standard.
19337	Biddeford. H. L. Merrill	Low.
19255	Boothbay. Mrs. G. V. Adams	Well above standard.
19257	Boothbay Harbor. Blue Ship Tea Room	Well above standard.
19256	Boothbay Harbor. E. L. Porter Co	Well above standard.
19367	Brownville Jct. A. M. Billodeau	Low.
19273	Brunswick. Charles Chanon, Jr	Well above standard.
19272	Brunswick. Spear Folks	Well above standard.
19198	Camden. E. E. Boynton	Well above standard.
19199	Camden. Burkett Bros.	Slightly below standard.
19200	Camden. George Mixer	Slightly below standard.
19222	Castine. Ethel Noyes	Well above standard.
19181	Columbia Falls. Mary R. Chandler	Well above standard.
19182	Columbia Falls. J. D. Hathaway, Jr	Well above standard.
19306	Dover. D. E. Foulkes	Low.
19254	East Boothbay. Race & Co	Well above standard.
19394	East Deering. W. A. Oxnard	Slightly below standard.
19294	East Sullivan. Gibson Hanah	Low.
19164	East Surry. Mrs. W. B. Stanley	Low.
19161	Ellsworth. Mrs. Asunta Luchini	Well above standard.
19160	Ellsworth. H. W. Morang	Slightly below standard.
19162	Ellsworth. R. H. Smith	Well above standard.

*Explanation of terms. Lawful, just above standard. Well above standard, at least 1 per cent above. Slightly below, not more than 1 per cent below standard. Low, more than 1 per cent below standard.

ICE CREAM—Continued.

Station number.	TOWN AND DEALER.	Results of Examination*
19163	Ellsworth. H. L. Wheelden	Low.
19362	Farmington. Marr's Drug Store	Slightly below standard.
19361	Farmington. Norton's Candy Store	Low.
19363	Farmington. Tarbox & Whittier	Well above standard.
19232	Ft. Fairfield. Ft. Fairfield Drug Co.	Slightly below standard.
19233	Ft. Fairfield. Scates & Co.	Well above standard.
19231	Ft. Fairfield. Smith's Kandy Kitchen	Well above standard.
19228	Ft. Kent. Geo. Savage	Well above standard.
19227	Ft. Kent. M. J. Wobby	Well above standard.
19307	Foxcroft. E. H. Nickerson	Well above standard.
19241	Gardiner. R. W. Hill	Well above standard.
19242	Gardiner. Jackson Drug Store	Lawful.
19213	Hallowell. Geo. Avata	Low.
19214	Hallowell. Victor Cantom	Slightly below standard.
19212	Hallowell. Guy M. Towle	Well above standard.
19183	Harrington. Geo. S. Anderson	Low.
19180	Harrington. F. W. Randall	Low.
19245	Houlton. Cronkite & Fleming	Well above standard.
19243	Houlton. John A. Miller	Slightly below standard.
19244	Houlton. John K. Palmer	Well above standard.
19352	Lewiston. Alden's Drug Store	Well above standard.
19265	Lewiston. Henry D. Begin	Slightly below standard.
19253	Lewiston. Buckley-O'Connell	Slightly below standard.
19270	Lewiston. Coon Ice Cream Co.	Slightly below standard.
19378	Lewiston. Coon Ice Cream Co.	Lawful.
19379	Lewiston. Coon Ice Cream Co.	Well above standard.
19266	Lewiston. J. E. Cote	Lawful.
19264	Lewiston. E. Dumont & Co.	Slightly below standard.
19249	Lewiston. Alton Grant	Well above standard.
19252	Lewiston. F. J. McCorey	Slightly below standard.
19345	Lewiston. Riker Janes	Lawful.
19354	Lewiston. Riker Janes	Well above standard.

*Explanation of terms. Lawful, just above standard. Well above standard, at least 1 per cent above. Slightly below, not more than 1 per cent below standard, Low, more than 1 per cent below standard.

ICE CREAM—Continued.

Station number.	TOWN AND DEALER.	Results of Examination*
19251	Lewiston. Geo. Ross	Well above standard.
19229	Limestone. Edward McDonald	Well above standard.
19230	Limestone. E. F. Mantle	Well above standard.
19287	Lincoln. W. L. Clapp	Well above standard.
19248	Lisbon. N. Beal	Well above standard.
19250	Lisbon. Mathew Frangedakis	Slightly below standard.
19246	Lisbon Falls. Kennebec Fruit Co	Well above standard.
19247	Lisbon Falls. C. F. Wakely	Well above standard.
19184	Machias. Stark & Sterrett	Slightly below standard.
19286	Mapleton. J. F. Eachren	Well above standard.
19365	Milo. M. B. Forsa	Well above standard.
19366	Milo. W. S. Owen	Low.
19167	No. East Harbor. Amedso Bertucci	Lawful.
19204	North Haven. Duncan & Stone	Low.
19280	North Haven. Duncan & Stone	Well above standard.
19203	North Haven. Francis Mills	Low.
19368	Old Town. Morin Bros	Well above standard.
19283	Portland. Deering Ice Co	Slightly below standard.
19333	Portland. I. F. Lord & Son	Well above standard.
19335	Portland. Moustakis Bros	Well above standard.
19281	Portland. Munjoy Ice Cream Co	Slightly below standard.
19284	Portland. Simmons & Hammond	Slightly below standard.
19334	Portland. The Spear Folks	Well above standard.
19332	Portland. Mrs. J. J. Thuss	Low.
19282	Portland. Turner Center Dairying Association	Lawful.
19285	Portland. West End Dairy	Slightly below standard.
19302	Richmond. W. A. Bebber	Well above standard.
19301	Richmond. E. B. Rankins	Low.
19393	Richmond. E. B. Rankins	Slightly below standard.
19423	Richmond. E. B. Rankins	Well above standard.
19202	Rockland. J. H. Meservey	Lawful.
19201	Rockland. John S. Randlett	Low.

*Explanation of terms. Lawful, just above standard. Well above standard, at least 1 per cent above. Slightly below, not more than 1 per cent below standard, Low, more than 1 per cent below standard.

ICE CREAM—Continued.

Station number.	TOWN AND DEALER.	Results of Examination*
19211	Rockland. Mrs. E. W. Thurlow	Low.
19219	Sargentville. N. M. Robbins	Low.
19170	Seal Harbor. S. B. Childs	Low.
19169	Seal Harbor. Gus Freberg	Low.
19168	Seal Harbor. Jordan Pond House	Well above standard.
19191	Searsport. Searsport Drug Co.	Lawful.
19156	Sebasco. Sebasco Est. Co	Low.
19220	Sedgwick. R. M. Buckminster	Well above standard.
19277	Skowhegan. G. F. Burton	Well above standard.
19276	Skowhegan. Peter Debe	Lawful.
19275	Skowhegan. Lewra Bros	Lawful.
19279	Skowhegan. Sampson & Avore	Well above standard.
19278	Skowhegan. F. E. Sawyer	Well above standard.
19274	Skowhegan. J. B. Simonds	Well above standard.
19221	South Brooksvillle. Ray C. Gray	Well above standard.
19293	So. Gouldsboro. Henry Hamilton	Slightly below standard.
19292	So. Gouldsboro. Arthur Sargent	Lawful.
19165	S. W. Harbor. Mrs. William Lawton's Tea Room	Well above standard.
19166	S. W. Harbor. D. K. Mayo	Slightly below standard.
19370	Stillwater. Charles H. Russell	Well above standard.
19369	Stillwater. H. C. Sibley	Well above standard.
19210	Thomaston. Whitney & Brackett	Well above standard.
19207	Vinal Haven. H. Y. Carver & Son	Low.
19206	Vinal Haven. W. E. Lincoln	Low.
19205	Vinal Haven. Tom Saranto	Low.
19209	Warren. J. C. Munsey	Low.
19234	Waterville. Fortier's Waterville Drug Store	Well above standard.
19235	Waterville. Phillip Gigure	Well above standard.
19240	Waterville. W. A. Hager & Co	Well above standard.
19237	Waterville. J. D. Perent	Well above standard.
19238	Waterville. D. E. Stone	Well above standard.
19239	Waterville. Verzonia Bros	Low.

*Explanation of terms. Lawful, just above standard. Well above standard, at least 1 per cent above. Slightly below, not more than 1 per cent below standard. Low, more than 1 per cent below standard.

ICE CREAM—Concluded.

Station number.	TOWN AND DEALER.	Results of Examination*
19236	Waterville. Micheal Wagem & Bros.	Lawful.
19364	W. Farmington. Turner Center Dairying Association	Slightly below standard.
19189	Winterport. F. C. Atwood	Low.
19190	Winterport. Mrs. W. R. Fernald	Well above standard.
19298	Woolwich. George Cristie	Lawful.
19299	Woolwich. Nelson Rice	Slightly below standard.

*Explanation of terms. Lawful, just above standard. Well above standard, at least 1 per cent above. Slightly below, not more than 1 per cent below standard. Low, more than 1 per cent below standard.

IMITATION CIDER VINEGAR.

Adulterated imitation vinegars delivered to inspector when he tried to purchase cider vinegar in 1919. No. 19316 was sold as pure cider vinegar. It was a distilled vinegar of about two-thirds lawful strength colored to imitate cider vinegar. No. 19398 was a very imperfectly made molasses vinegar with about ten per cent of molasses solids in the ash and less than half lawful acid. They were reported as adulterated and misbranded and hearings were recommended. No. 19321 was of lawful strength but was a distilled vinegar colored in imitation of cider vinegar. Reported as adulterated and hearing recommended.

Station number.	TOWN AND RETAIL DEALER.	Claimed to have been Purchased From.
19316	Portland. Max Goldstein	Maine Pickling Company, Portland, Me.
19321	Randolph. W. L. Moody	Lutz-Shraum, Boston.
19398	W. Cumberland. W. H. Pearson Co.	Geo. Emery, Walnut Hill.

VINEGAR.

Used alone under the Maine Pure Food Law vinegar is a product made from apple cider without addition. A good well made cider vinegar will carry from 5 to 6 per cent of acetic acid. A vinegar carrying 4 per cent acetic acid is of lawful strength. As a vinegar carrying 4 per cent is lawful it has come about that the large makers of vinegar reduce their product to about four per cent by the addition of water. This is an adulteration but is allowed provided the vinegar is properly labelled to show that this manipulation has been made. In the tables that follow the samples of vinegar are grouped into classes as shown by laboratory examination. It is possible, but not likely, that in the group "Cider vinegar reduced to standard strength by addition of water," there are included samples of poorly made cider vinegar.

UNADULTERATED CIDER VINEGAR.

Table showing the results of the analyses of samples of pure well made cider vinegars purchased in 1919. These samples were high in acid content (about 5 per cent) and were well made cider vinegars that had not been reduced. They were worth a fourth more than the reduced vinegars.

Station number.	TOWN AND RETAIL DEALER.	Brand and Wholesale Dealer.
19311	Augusta. L. S. Young	"Pure Cider Vinegar." Leland Block, Oakland.
19407	Bath. H. W. Crossman	"Pure Cider Vinegar." H. J. Heinz & Co., Boston.
19341	Bath. Cut Price Market	"Pure Cider Vinegar." Bottled by E. W. Balch, Portland.
19374	Brownville. A. A. Price	"Cider Vinegar." C. S. Stickney, Brownville.
19383	E. New Portland. Fred Walton	"Pure Cider Vinegar." Own make.
19373	(Town not given). M. G. Brackett Co.	"Pure Cider Vinegar." Charles F. Deorth, Foxcroft.
19348	Lewiston. E. B. Palmer & Co.	"Pure Cider Vinegar." Bought of unknown farmer.
19397	Portland. Geo. C. Shaw	"Pure Cider Vinegar." Wm. Pillsbury.
19355	Waterville. H. E. Pomealeau	"Pure Cider Vinegar." Own make.

CIDER VINEGARS REDUCED TO STANDARD STRENGTH BY ADDITION OF WATER.

Table showing results of analyses of samples purchased in 1919. These samples ran from 3.8 per cent to 4.2 per cent acetic acid. In reducing them from their normal content of 5 per cent or more of acetic acid, some manufacturers allow a fair margin of safety while others evidently trust to getting by without prosecution if they approximate the lawful strength. At the present price of vinegar this little fraud is profitable. In the table below there is first given the vinegars that are 4 per cent in strength, and below that the list of vinegars that were slightly under lawful strength. All of these samples were passed. The samples are arranged alphabetically by towns.

Up to lawful strength of 4 per cent acetic acid.

Station number.	Town and Retail Dealer.	Brand and Wholesale Dealer.
19419	Albion. L. F. Gannon	"Pure Cider Vinegar." Dealer purchased of a country producer. Name not given.
19308	Augusta. E. B. Foster	"Pure Cider Vinegar, J. E. Jewett, Lowell, Mass." Holmes Swift.
19310	Augusta. Great Atlantic & Pacific Tea Co.	"Pure Clarified Cider Vinegar. From Apples. Diluted to 4 per cent acid strength." The Great Atlantic & Pacific Tea Co.
19312	Augusta. Merrill Brothers	"Pure Country Cider Vinegar. Hatchett brand. Reduced to 4 per cent acid strength." Twichell & Champlin Co.
19322	Augusta. Pantaude Brothers	"Pure Cider Vinegar." Fuller-Holway Co.
19314	Bath. Bath Merchantile Co	"Pure Cider Vinegar. Reduced to 40 gram strength." John Bird Co., Rockland.
19406	Bath. O. F. Rullman	"Pure Cider Vinegar." Wholesaler not known.
19403	Bath. S .Strout & Co	"Pure Cider Vinegar." Cummings Bros., Portland.
19404	Bath. Wilson & Armstrong	"Pure Cider Vinegar." Fuller-Holway Co., Augusta.
19376	Brownville Junction. S. Capans	"Pure Cider Vinegar. Fermented. Reduced 4 per cent acetic strength. Food products of quality. L & S." Lutz & Shraum Co., Boston, & Pittsburg.
19415	Damariscotta Mills. E. B. Hall	"Pure Cider Vinegar." D. W. True & Co., Portland.
19331	Fairfield. Marcoux-Foster	"Pure Cider Vinegar." Frank Norwell, Fairfield.
19330	Fairfield. W. W. Nye & Co	"Pure Cider Vinegar." Guptill Bros., Winslow.
19340	Hallowell. M. B. Clements	"Pure Cider Vinegar. Navinco Brand. Distributed by National Vinegar Co., Buffalo, N. Y. Fermented Cider Vinegar. Made from apples." Milliken Tomlinson, Portland.

CIDER VINEGARS REDUCED TO STANDARD STRENGTH BY ADDITION OF WATER—Continued.

Station number.	TOWN AND DEALER.	Results of Examination.
19313	Hallowell. D. C. Stallins	"Pure Cider Vinegar." Wholesaler unknown.
19417	Hope. L. P. True & Co	"Pure Cider Vinegar." D. W. True & Co., Portland.
19409	Kittery. Farmers' Union	"Pure Cider Vinegar." Charles E. Moody & Co., Boston.
19411	Kittery. Kittery Grocery Co	"Pure Cider Vinegar. Duffy's Gold Seal apple cider vinegar reduced to 40 grams strength made and guaranteed by Duffy Mott Co., New York." Milliken Tomlinson Co., Portland.
19360	Lewiston. Marcous & Harvey	"Pure Cider Vinegar. Distilled and sugar vinegar." Lutz-Shraum Co., Boston.
19347	Lewiston. The Mohican Co	"Pure Cider Vinegar. C. C. C. brand. Cascade Cider Co., Springville, N. Y. Reduced with water to 4½ per cent acetic acid. Reduced cider vinegar made from apples. Fermented." Bought through N. Y. office.
19353	Lewiston. Rowe & Woodbury	"Pure Cider Vinegar." E. W. Gross Co., Auburn.
19350	Lewiston. I. Sumard & Co	"Pure Cider Vinegar. Imperial Brand apple cider vinegar. Reduced to 40 grams." D. W. True & Co., Portland.
19385	Livermore Falls. Livermore Falls Market	"Pure Cider Vinegar." Wholesaled by an unknown farmer.
19328	Madison. The Madison Union Coop. Store	"Pure Cider Vinegar. Douglas Packing Co., Excelsior Brand. Apple cider from selected apples reduced to 4 per cent." T. R. Savage, Bangor.
19371	Milo. Hoskins Brothers	"Pure Cider Vinegar." Chas. Haywood & Co., Bangor.
19323	Portland. Carl J. Blom	"Pure Cider Vinegar. Reduced to 4 per cent acid strength." E. E. Clifford, Portland.
19324	Portland. Brown-Bishop Co	"Pure Cider Vinegar. Fermented. Pure apple cider vinegar. Reduced to 4 per cent acid strength. Old Colony Brand." Maine Grocery Co.
19342	Portland. Maine Pickling Co	"Pure Cider Vinegar. Maine Brand." Maine Pickling Co., Portland.
19325	Portland. M. Rich	"Pure Cider Vinegar. Shamokin pure & good products. Star Brand. Reduced to 40 grams." C. A. Weston Co., Portland.
19388	Presque Isle. R. M. Barker	"Cider Vinegar." Milliken Tomlinson Co., Presque Isle.
19317	Saco. E. H. Fairfield	"Pure Cider Vinegar." Wholesaler an unknown farmer.
19329	Skowhegan. Tash & Groder	"Pure Cider Vinegar. Reduced to 40 grams." Conant & Patrick, Portland.
19412	South Eliot. Thomas F. Staples	"Pure Cider Vinegar. Made from apples. Reduced to 4 per cent acid." Haskell Adams, Dover, N. H. Branch office.

CIDER VINEGARS REDUCED TO STANDARD STRENGTH BY ADDITION OF WATER—Concluded.

Station number.	TOWN AND RETAIL DEALER.	Brand and Wholesale Dealer.
19416	West Rockport. Knox Coopage Co.	"Pure Cider Vinegar. Seal Brand. Apple cider vinegar. Reduced to 40 grams. Duffy-Mott Co., Mfg." John Bird Co., Rockland.
19414	York Harbor. Putnam Grocery Co.	"Pure Cider Vinegar. Made from apples. Reduced to 4 per cent acid." Haskell Adams, Dover, N. H.
19413	York Village. G. F. Preble	"Pure Cider Vinegar. Reduced to 40 grams. Shamokin pure food products, Shamokin, Pa." Silas Pierce & Co., Ltd., Portsmouth, N. H.

CIDER VINEGAR REDUCED BY ADDITION OF WATER MUCH BELOW LAWFUL STRENGTH OF 4 PER CENT ACETIC ACID.

These samples give evidence of having been well fermented from apple cider but were reduced to unlawful content by addition of water. They were reported as adulterated and hearigns were recommended.

Station number.	TOWN AND RETAIL DEALER.	Claimed to have been Purchased From.
19372	Milo. C. W. Mayo	Thurston & Kingsbury & Co., Bangor.
19395	Portland. Johnson Public Market	Maine Grocery Co., Portland.
19390	Presque Isle. McEacheron & Tribou	Aroostook Wholesale Co., Presque Isle.

CIDER VINEGAR REDUCED SLIGHTLY BELOW LAWFUL STRENGTH BY ADDITION OF WATER.

Table showing results of analyses of samples purchased in 1919 and arranged alphabetically by towns.

Station number.	TOWN AND RETAIL DEALER.	Brand and Wholesale Dealer.
19309	Augusta. Geo. D. Haskell & Son	"Pure Cider Vinegar. Apple Cider Vinegar. Francis H. Leggitt, Mfg.' Fuller Holway Co.
19405	Bath. R. D. Moulton	"Pure Cider Vinegar." Oscar Holway Co., Bath.
19400	East Deering. W. J. Lucas	"Pure Cider Vinegar." Milliken-Tomlinson, Portland.
19320	Gardiner. C. M. Day	"Pure Cider Vinegar." Wholesaler not known.
19319	Gardiner. Gray-Hildreth Co	"Pure Cider Vinegar." E. E. Clifford, Portland.
19399	Gray Con. J. B. Hall	"Pure Cider Vinegar. Naminco Brand. Made from apples. Reduced 4 per cent acid strength. National Vinegar Co., Inc.. Buffalo." Conant Patrick. Portland.
19410	Kittery. C. M. Prince & Son	"Pure Cider Vinegar. Made from apples. Reduced 4 per cent." Charles E. Moody & Co., Boston.
19382	Leeds Junction. F. A. Babbett	"Pure Cider Vinegar. Creamer Bros. Cider Co." T. G. Davis Co., Lewiston.
19359	Lewiston. Fred I. Nells	"Pure Fermented Apple Cider Vinegar. Kistler Vinegar Works. Reduced to 40 grams acid strength." F. G. Davis Co., Lewiston.
19346	Lewiston. H. Shuffer	"Water Lily Brand Apple Cider Vinegar. Reduced to 40 gram strength." H. S. Melcher Co., Portland.
19384	Livermore Falls. H. E. Purinton	"Fermented Pure Apple Cider Vinegar. Old Colony Brand. Reduced to 4 per cent. acid strength." Maine Grocery Co., Portland.
19326	Madison. F. A. Gilman	"Pure Cider Vinegar. Shamokin pure food products. Store Brand. Reduced to 40 grams." Hannaford Bros., Portland.
19327	Madison. C. W. Green Gro. Co	"Marvel Brand Pure Cider Vinegar. Reduced to 40 grams." C. A. Weston & Co., Portland.
19396	Portland. G. F. Hoover	"Pure Cider Vinegar. Reduced 4 per cent acid strength." Hannaford Bros., Portland.
19315	Portland. R. R. Reed	"Pure Cider Vinegar." Thompson-Hall, Portland.
19389	Presque Isle. Aroostook Cooperative Co	"Pure Cider Vinegar." E. E. Clifford & Co., Portland.
19392	Presque Isle. Max X. Beaulieu	"Cider Vinegar." Milliken Tomlinson Co., Presque Isle.
19387	Presque Isle. R. H. McDonald	"Pure Cider Vinegar." E. E. Clifford & Co., Portland.
19391	Presque Isle. H. J. McGuire & Co	"Cider Vinegar." Aroostook Wholesale Grocery Co., Presque Isle.
19318	Saco. Edwin W. Fay	"Pure Cider Vinegar." D. W. True & Co., Portland.
19343	Saco. E. K. Weymouth	"Pure Cider Vinegar. Maine Brand." Maine Pickling Co., Portland.
19357	Waterville. H. Bomey	"Pure Cider Vinegar. Made from apples. Reduced to 4 per cent acid strength. Haskell Adams, Boston.
19358	Winthrop. Winthrop Market	"Pure Cider Vinegar." Fred Soper, Monmouth.

CIDER VINEGAR IMPERFECTLY FERMENTED.

Table showing the results of samples of poorly made cider vinegar purchased in 1919. They were locally made by farmers. Are apparently made from apple cider but very imperfectly fermented. No. 19596 was less than one-seventh and 19351 a little more than one-third lawful strength. The other samples carried about three-fourths proper per cent of acetic acid. They were reported as adulterated and hearings were recommended.

Station number.	TOWN AND RETAIL DEALER.	Claimed to have been Purchased From.
19402	China. J. S. Rowe	F. W. Gerald, China.
19420	E. Vassalboro. Geo. H. Coles	M. E. Brann, Vassalboro.
19381	E. Wilton. H. H. Johnson	Arlean McLaughlin.
19386	Greene. J. M. Tangway	Earl Richardson, Greene.
19349	Lewiston. Cut Price Market	L. Abramson, former owner.
19351	Lewiston. A. Marern & Co	L. Davis, Lewiston.
19418	Montville. Halldale Gro. Store	Alonzo Raynes, No. Montville.
19596	South Berwick. Eugene Ball	Own make.
19401	South China. A. E. Brown & Co	Thomas Sawyer, S. China.
19356	Waterville. Elmer L. Craig	H. E. Craig, Fairfield.

DISTILLED VINEGARS PROPERLY BRANDED AND OF LAWFUL STRENGTH.

Table showing the results of distilled vinegars purchased in 1919. These were sold the inspector when he asked for cider vinegar. But the vinegar was properly labelled. A distilled vinegar is the product of acetous fermentation of dilute alcohol. These vinegars are free from ash and other foreign matter.

Station number.	TOWN AND RETAIL DEALER.	Brand and Wholesale Dealer.
19408	Bath. W. E. Chase Co	"Pickling & Table Vinegar. Distilled from corn, rye, barley." H. J. Heinz & Co., Pittsburg, Pa.
19375	Brownville. P. P. Gerry	"Pure Cider Vinegar." Rex Amber Sugar Vinegar. H. J. Heinz & Co., Pittsburg.

CLAMS.

To sell water camouflaged as food at the price of clams, butter, milk, "Hamburg" steak and similar food products is a constant temptation to the man who cares not for his neighbor but desires to fatten his pocket-book from an unthinking and often helpless public. A study made by the writer in conjunction with Doctor W. O. Atwater more than a generation ago and published in the Report of the U. S. Fish Commissioner for 1888 clearly showed the "floating" or "fattening" of oysters by taking them from the salt water beds and placing them in brackish waters instead of adding to, detracted from the nutritive value. The plumped oysters were not fattened but were merely dilated with water due to osmosis.

Not until the enactment of the food laws in 1895 was it possible to attempt to put a stop to this unrighteous practice. As opened oysters enter into interstate shipments the undue watering has been largely eliminated through the activities of the Federal Pure Food officials. But the watering of clams still continues, and is so far as Maine is concerned and to quite an extent in interstate commerce much as was the case with oysters a dozen years ago. With the increased cost of foods, their scarcity and the war conditions there has been an unusual chance for increase in pecuniary frauds. Watered clams look better, that is whiter and plumper, and the improved appearance makes easier sale of clams and water than of unwatered clams. There is every reason from the standpoint of the purchaser why clams should not be allowed to come in contact with fresh or brackish water. Clams which are not soaked at all and are well drained should contain about one-fifth their weight in dry matter and be at prices which they can be sold in Maine a relatively cheap source of animal protein.

For the purpose of comparison of clams on sale with authenticated specimens handled under known conditions and from salt and brackish waters, the following specimens were collected and examined. Those from the first lot were opened in the laboratory and from the second lot at the flats.

Table showing liquids and dry matter of clams opened raw compared with clams dipped for two minutes in boiling salt water and boiling fresh water before opening.

Station number.	SOURCE OF CLAMS	Opened Raw		Dipped in Hot Salt Water		Dipped in Hot Fresh Water	
		Liquids	Solids	Liquids	Solids	Liquids	Solids
		%	%	%	%	%	%
11079	North Haven "Rock"	53.2	21.2	58.1	19.8	59.2	19.7
11080	North Haven "Mud"	46.7	19.8	45.8	19.2	50.8	18.6
11081	Keag River	40.9	22.4	40.2	20.7	54.0	20.4

Table showing composition of clams from different flats. First sample was dug without washing in fresh water. Second sample washed in fresh water after shucking.

Station number.			Free Liquids	Solids	Salt
19604	Dug in creek below western division track	Unwashed	16.56	21.08	1.74
19605	of B & M	Washed	6.68	18.95	1.60
19606	Dug on sand spits below the western divi-	Unwashed	10.56	21.95	1.99
19607	sion track of B & M	Washed	8.00	21.88	1.60
19608	Dug in part of flats known as battle	Unwashed	16.61	19.89	1.71
19609	ground above western division tracks	Washed	9.90	18.02	1.37
19610	Dug in part of flats known as James'	Unwashed	13.27	18.87	1.28
19611	point above track of western division of B & M	Washed	9.62	17.42	1.30

OPENED CLAMS.

Results of examination of samples collected in 1919-20 by the inspectors. For the most part these were purchased without the inspector making himself known, and are what the consumer would have received, except that the containers were paper and absorbed more or less of the liquids thus making the samples appear better than they really were. Good fresh opened well drained clams will carry not more than 10 per cent of liquids and not less than 17 per cent solids. The samples are arranged alphabetically by towns.

Station number	TOWN AND DEALER.	Free Liquid	Solids	REMARKS.
19127	Biddeford. York Harbor Fish Market	3.32	19.17	Samples carrying 12 per cent or less of free liquids were passed. Free liquids 12 to 15 per cent dealer warned. More than 15 per cent free liquids hearings were recommended. Samples carrying not less than 18 per cent solids were passed. Solids between 17 to 18 per cent the dealer was warned. Less than 17 per cent solids hearings were recommended.
19101	Boston. Charles Farillo	36.95	17.43	
19102	Boston. Charles Farillo	36.47	20.01	
19083	Pine Point. Frank H. Barker	17.80	13.13	
19088	Pine Point. Loren Burnham	16.79	12.16	
19104	Pine Point. Alexander Gendron	9.74	17.09	
19087	Pine Point. Charles Gendron	14.54	14.61	
19084	Pine Point. Fred Googins	16.44	14.62	
19086	Pine Point. William Green	18.73	12.32	
19090	Pine Point. Charles Haring	12.99	15.42	
19097	Pine Point. Leavitt Bros	24.88	22.75	
19093	Pine Point. Ambrose A. Lothrope	8.89	14.07	
19099	Pine Point. Joseph Mains	13.84	18.13	
19098	Pine Point. George T. Seavey	8.26	20.0	
19094	Pine Point. James E. Seavey	15.69	12.82	
19103	Pine Point. Elmer Skillings	14.97	18.45	
19124	Pine Point. Elmer Skillings	12.10	21.15	
19095	Pine Point. H. J. Skillings	7.06	14.43	
19105	Pine Point. Howard Skillings	33.72	21.67	
19106	Pine Point. Howard Skillings	35.91	20.06	
19107	Pine Point. Howard Skillings	6.10	19.84	
19108	Pine Point. Howard Skillings	5.00	21.18	
19123	Pine Point. Howard Skillings	8.18	23.06	

OPENED CLAMS—Concluded.

Station number	TOWN AND DEALER.	Free Liquid	Solids	REMARKS.
19126	Pine Point. Louis Skillings	18.58	16.91	Samples carrying 12 per cent or less of free liquids were passed. Free liquids 12 to 15 per cent dealer warned. More than 15 per cent free liquids hearings were recommended. Samples carrying not less than 18 per cent solids were passed. Solids between 17 to 18 per cent the dealer was warned. Less than 17 per cent solids hearings were recommended.
19100	Pine Point. F. H. Snow	25.99	21.83	
19109	Pine Point. F. H. Snow	7.42	22.08	
19593	Pine Point. F. H. Snow	15.76	16.58	
19125	Pine Point. Rubin Snow	21.72	14.78	
19082	Pine Point. Charles C. Turner	19.21	13.37	
19096	Pine Point. Charles C. Turner	18.95	17.41	
19092	Pine Point. Orville Varney	13.93	15.15	
19091	Pine Point. John Peter Welch	10.57	14.26	
19089	Pine Point. Daniel Williams	11.11	13.17	
19119	Portland. Eben Doughty	19.32	15.96	
19119	Portlnad. Eben Doughty	8.79	20.22	
19120	Portland. Munjoy Fish Market	18.68	14.09	
19121	Portland. Runletts Markett	18.37	17.08	
19499	Scarboro. H. P. Nelson	31.28	11.31	
19110	Waterboro. Carll Bros	20.14	15.68	
19111	Waterboro. Carll Bros	30.88	15.48	
19112	Waterboro. Carll Bros	23.69	14.92	
19113	Waterboro. Carll Bros	27.92	14.69	
19114	Waterboro. Carll Bros	15.61	19.52	
19115	Waterboro. Carll Bros	31.38	16.18	
19085	West Scarboro. Fred Googins	15.34	13.27	
19118	West Scarboro. Fred Googins	9.96	16.63	

EXTRACT OF GINGER.

This is a flavoring extract. One sample was purchased from J. I. Sheridan, 156 Lisbon Street, Lewiston. This was labelled as made by the Park Davis Company of Detroit, Michigan and was found to be in accordance with the food standard.

SCALLOPS.

The scallop situation is much like that of clams. The fishermen claim that it is necessary to wash the scallops in fresh water to remove the scum-like coating from them. If this washing did not increase both the weight and the bulk of the scallops the fisherman would loubtless do all of the washing in salt water.

One sample of scallops that was purchased in December from the Portland Public Market was said to come from the Gloucester Fish Company, Gloucester, Mass. While this did not run as high in solids as we would expect good Maine scallops to, this was probably due to the fact that the scallops had been washed in fresh water and also carried too much liquid.

RAISINS.

A complaint that seeded raisins contained considerable grit led to the collection of quite a number of samples. While most of the samples examined carried no more insoluble ash than one would expect in raisins, quite a number of samples were found to have from three-quarters to 1 per cent of sand. Upon investigation it was found that this was due to the fact that when the raisins were drying there was a heavy sand storm and they were not properly cleansed afterward. Relative to the brands that were thus contaminated, these are not given, because samples from exactly the same brand were found to be free from sand. This case was cleared up by the Chief of the Bureau of Inspections as well as it could be. These goods had become intermixed within the State and it was not possible to make Federal cases. As it is commonly known, the grapes are dried in California in the open air and are subject to contamination. It is not likely that raisins will again come to the market so heavily loaded with sand.

August, 1920

MAINE
AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE.
CHAS. D. WOODS, Director

ANALYSTS.

James M. Bartlett
Roydon L. Hammond
Elmer R. Tobey
C. Harry White

Official Inspections

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COMMERCIAL FEEDING STUFFS, 1919-20

Chas. D. Woods.

The Commissioner of Agriculture is the executive of the law regulating the sale of feeding stuffs in Maine. It is the duty of the Director of the Maine Agricultural Experiment Station to make the analyses of the samples collected by the Commissioner, and to publish the results of the analyses together with the names of the persons from whom the samples were obtained, and such additional information as may seem advisable.

Note. All correspondence relative to the inspection laws should be addressed to the Bureau of Inspections, Department of Agriculture, Augusta, Maine.

FEEDING STUFFS INSPECTION

STATEMENT BY A. M. G. SOULE, CHIEF BUREAU OF INSPECTIONS DEPARTMENT OF AGRICULTURE, AUGUSTA

Feeding Stuffs received attention during 1919 with the exception of a short period during the summer. Bearing in mind the many complications arising in the manufacture and transportation of feeding stuffs by strikes and riots, we have at all times endeavored to be as tolerant as we could, actuated by the desire to impress upon the feed manufacturers and dealers located within and beyond the borders of Maine, the fact of our willingness to cooperate with them in facilitating business whenever consistent with the feeding stuffs laws of the State. It is our belief that the brands which we found upon analysis to be below standard were, with but few exceptions, unintentionally so on the part of the manufacturers. Prosecution of one concern within the State seemed to be warranted, as a flagrant violation was detected, and a fifty dollar fine was paid. A few local concerns also paid fines for misbranding. With the prices of feeds as high as they are, we have endeavored in every possible way to see that the users of them have received the full benefit of the law. If difficulties arose with products entering into interstate shipment, and the situation warranted such action, the cases were referred to the Federal Department. Our recommendations to the United States Bureau of Chemistry, made upon the strength of our collaborating official's commission, were always met in a direct courteous manner, which encouraged us in our cooperative work. The following table briefly outlines the scope of our work with relation to feeding stuffs:

Number of brands registered	630
Number of samples drawn	470
Number of hearings	98
Number of carloads seized	3

REGISTRATION AND RESULTS OF INSPECTION.

CHAS. D. WOODS.

The following pages contain the report of the analysis of commercial feeding stuffs made since the publication of Official Inspections 92.

In the left hand column of the tables will be found listed the name of each brand of feeding stuff registered in Maine in 1919 or 1920, the name of the manufacturer, the list of ingredients, and the guaranteed analysis as given on the certificate of registration filed with the Commissioner of Agriculture. Unregistered brands of which samples have been examined are also included in the list. Unless otherwise stated all of the brands, samples of which are here reported, were registered in 1920. The feeds are grouped into classes and in those classes the names of the manufacturers are arranged alphabetically. In the right hand column the results of the examination of the samples of each brand are discussed. The number of samples examined, how many were in accord with guaranty, how many were not in accord and in what respects, and any other information that has a bearing on the lawful sale of the goods, are given for each brand. In the discussion, when a sample is spoken of as "slightly" below (in the case of fiber, above) guaranty, it means that the deviation from guaranty was so small that another sample from the same lot of goods might be found in accord. The significance of a "slight" deviation depends to a considerable extent upon the findings in regard to the other constituents of the same sample and other samples of the same brand.

Because deficient samples are reported in this bulletin should not be taken to mean that cases have been passed. All discrepancies between guarantees and analyses are reported to the Commissioner of Agriculture for appropriate action; serious discrepancies in goods shipped from other states are reported by him to the Federal authorities for action under the United States law.

Anyone desiring to submit samples for free analysis MUST take those samples in accordance with the directions issued by the Department of Agriculture; copies of these directions may be obtained on application to the Commissioner of Agriculture, Augusta, or to the Director of the Station at Orono.

Table showing registrations of feeding stuffs and results of examination of samples.

ANIMAL REFUSES—MEAT (AND BONE) SCRAPS.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Greene's Meat Mash for Poultry. Greene Chick Feed Co., Marblehead, Mass. Composed of fish scraps, meat and bone scraps, corn meal, hominy feed, grain screenings, shell lime, alfalfa meal, wheat bran and salt. Contains not more than 7 per cent crude fiber and not less than 3 per cent fat and 12 per cent protein.	**Slightly low in protin, high in fiber and in accord with guaranty in fat. Misbranded as no meat meal was found.**
Ground Beef Scraps. John C. Dow Co., Boston, Mass. Composed of meat scraps. Contains not more than 0 per cent crude fiber and not less than 12 per cent fat and 43 per cent protein. Registered in 1919.	One official sample. In accord with guaranty in fiber, high in fat; low in protein.
Meat & Bone Poultry Scrap. Whitman & Pratt Rendering Co., Boston, Mass. Composed of cooked meat and bone. Contains not more than 0 per cent crude fiber and not less than 12 per cent fat and 35 per cent protein. Registered in 1919.	One official sample. In accord with guaranty in protein and fiber; low in fat.
Protox Pure Ground Meat Scraps. The American Agricultural Chemical Co., Boston, Mass. Composed of meat scraps. Contains not more than 0 per cent crude fiber and not less than 10 per cent fat and 55 per cent protein. Registered in 1919.	Two official samples. One in accord with guaranty. The other in accord with guaranty in fiber and fat; somewhat low in protein.
Wirthmore Fish & Scrap Mash Feed with Milk Albumen. Chas. M. Cox Co., Boston, Mass. Composed of dried milk albumen, ground oats, ground barley, ground corn, corn gluten feed, hominy, wheat bran, wheat middlings, beet pulp, rolled oats, choice fine ground beef scraps, fish meal, buckwheat, edible bone meal and about ¼ of 1 per cent salt. Contains not more than 2.5 per cent crude fiber and not less than 4 per cent fat and 20 per cent protein.	One official sample. In accord with guaranty in protein and fat; high in fiber.
Wirthmore Growing Feed with Milk Albumen & Scraps. Chas. M. Cox Co., Boston, Mass. Composed of dried milk albumen, ground: wheat, corn, oats, barley, peas, milo maize, beet pulp, wheat middlings, red dog edible bone meal, and choice fine ground beef scraps. Contains not more than 4.5 per cent crude fiber and not less than 4.5 per cent fat and 15 per cent protein.	One official sample. In accord with guaranty.

BEET PULP.

Dried Beet Pulp. The Larrowe Milling Co., Detroit, Mich. Composed of residue of sugar beets dried after extraction of sugar. Contains not more than 20 per cent crude fiber, and not less than ½ per cent of fat and 8 per cent of protein.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
COMPOUNDED FEEDS FOR CATTLE, HORSES AND SWINE.	
Advanced Registry Dairy Feed. Clover Leaf Milling Co., Buffalo, N. Y. Composed of hominy feed, pure old process linseed meal, cocoanut oil meal, corn gluten feed, dried grains from barley malt and corn, wheat bran, wheat middlings, cottonseed meal, and one-half of 1 per cent fine table salt. Contains not more than 11 per cent crude fiber and not less than 5.50 per cent fat and 25 per cent protein.	One official sample. In accord with guaranty.
Armour's Dairy Feed. Armour Grain Co., Chicago, Ill. Composed of gluten feed, corn oil meal, cottonseed meal, linseed oil meal, cocoanut oil meal, wheat bran, oat shorts, oat middlings, oat hulls, hominy feed and 1 per cent salt. Contains not more than 14 per cent crude fiber and not less than 6 per cent fat and 22 per cent protein. Registered in 1919.	Two official samples. In accord with guaranty.
Armour's Hog Feed. Armour Grain Co., Chicago, Ill. Composed of hominy feed, meat meal, wheat bran, wheat middlings, linseed meal, peanut meal, oat middlings, oat shorts, oat hulls, lime and salt. Contains not more than 10 per cent crude fiber and not less than 5 per cent fat and 20 per cent protein.	One official sample. In accord with guaranty.
Armour's Stock Feed. Armour Grain Co., Chicago, Ill. Composed of hominy feed, ground corn, ground barley, wheat middlings, oat middlings, oat shorts, oat hulls, cottonseed meal, corn oil meal and ½ of 1 per cent salt. Contains not more than 12 per cent crude fiber and not less than 4 per cent fat and 12 per cent protein.	One official sample. In accord with guaranty.
Badger Monopoly Feed. Chas. A. Krause Milling Co., Milwaukee, Wisconsin. Composed of ground whole oats, corn and barley. Contains not more than 10 per cent crude fiber and not less than 3 per cent fat and 10 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Badger Stock Feed. Chas. A. Krause Milling Co., Milwaukee, Wisconsin. Composed of hominy feed, corn red dog, corn germ meal, wheat or rye middlings, oatmeal mill by-product (oat middlings, oat hulls, oat shorts), old process linseed oil meal and salt, kaffir and wheat bran. Contains not more than 12 per cent crude fiber and not less than 3.25 per cent fat and 10 per cent protein. Registered in 1919.	One official sample. In accord with guaranty in protein and fat; slightly high in fiber.
Bangor Union Ration. Bangor Farmers' Union, Bangor, Maine. Composed of linseed oil meal, gluten, cottonseed, mixed feed, bran, middlings, corn meal, stock feed, hominy, red dog, rye feed, ground oats. Contains not more than 26 per cent crude fiber and not less than 3½ per cent fat and 19 per cent protein.	One official sample. In accord with guaranty.
Bicorn Hog Feed. Chapin & Co., Chicago, Ill. Composed of tankage, corn germ meal, wheat middlings, hominy feed, corn feed meal, barley, oats, linseed meal, bone meal, gluten feed and salt. Contains not more than 6 per cent crude fiber and not less than 4.5 per cent fat and 17.5 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Big Q Dairy Ration. The Quaker Oats Co., Chicago, Ill. Composed of cottonseed meal, corn distillers' grains, hominy feed, yellow hominy feed, corn gluten feed, old process linseed oil meal, wheat middlings, and wheat bran (with ground screenings not exceeding mill run) oat meal mill by-product, oat middlings, oat hulls, oat shorts, 1 per cent salt. Contains not more than 10.5 per cent crude fiber and not less than 6 per cent fat and 21 per cent protein. Registered in 1919.	One official sample. In accord with guaranty in protein and fiber; slightly low in fat.
Blatchford's Lamb Meal. Blatchford's Calf Meal Factory, Waukegan, Ill. Composed of locust bean meal, barley meal, blood flour, linseed oil meal, rice polish, bean meal, re-cleaned cottonseed meal, corn meal, wheat flour, anise seed, salt. Contains not more than 6 per cent crude fiber and not less than 4 per cent fat and 20 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Clover Leaf Mills Hog Meal. Clover Leaf Milling Co., Buffalo, N. Y. Composed of wheat middlings, digester tankage, corn germ meal, linseed meal, corn feed meal, ground wheat screenings, molasses, and one-half of 1 per cent salt. Contains not more than 10 per cent crude fiber and not less than 5 per cent fat and 18 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Crosby's Ready Ration. E. Crosby & Co., Brattleboro, Vt. Composed of distillery dried grains, cottonseed meal, oil meal, malt sprouts, wheat bran, wheat middlings, hominy, ½ of 1 per cent salt. Contains not more than 9 per cent crude fiber and not less than 7 per cent fat and 25 per cent protein. Registered in 1919.	One official sample. In accord with guaranty in protein; high in fiber; low in fat.
Dairy Ration. Cornish Farmers' Union, Cornish, Maine. Contains not more than 13 per cent crude fiber and not less than 5 per cent fat and 19 per cent protein. Registered in 1919. The guarantees as given are from the inspector's slip. This feed was not registered at time of sale.	One dealer's sample. In accord with guaranty in protein; not examined for fiber and fat.
Dewey's Ready Ration. The Dewey Brothers Co., Blanchester, Ohio. Composed of eagle distillers' dried grains from corn, cottonseed meal, old process linseed oil meal, wheat bran, wheat middlings, hominy feed, malt sprouts, ½ per cent salt. Contains not more than 10 per cent crude fiber and not less than 6 per cent fat and 25 per cent protein. Registered in 1919.	Two official samples. One in accord with guaranty. The other in accord with guaranty in fiber and fat; slightly low in protein.
Diamond Dairy Feed No. 1. E. S. Woodworth & Co., Minneapolis, Minn. Contains not more than 21 per cent crude fiber and not less than 7 per cent fat and 11 per cent protein. Registered in 1919. The guarantees as given are from the inspector's slip. This feed was not registered at time of sale.	One official sample. In accord with guaranty.
Dirigo Horse Feed. Oscar Holway Co., Auburn, Me. Composed of crushed oats, crushed barley, cracked corn, bran and molasses. Contains not more than 6 per cent crude fiber and not less than 4 per cent fat and 9 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Domino 24½% Dry Dairy Ration. Nowak Milling Co., Buffalo, N. Y. Composed of cottonseed meal, corn gluten feed, old process linseed oil meal, cocoanut oil meal, fine alfalfa meal, wheat bran, corn feed meal, salt ½ of 1 per cent. Contains not more than 15 per cent crude fiber and not less than 4½ per cent fat and 24½ per cent protein.	One official sample. In accord with guaranty.
Economy Stock Feed. The Lake Erie Milling Co., Toledo, Ohio. Composed of corn, oats, oat hulls, oat groats, oat middlings, corn meal offal, flour middlings, barley and ½ of 1 per cent salt. Contains not more than 9 per cent crude fiber and not less than 4 per cent fat and 9 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Elm City Ready Ration. Merrill & Mayo Co., Waterville, Me. Composed of cottonseed meal, hominy feed, yellow hominy feed, corn distillers' grains and solubles, corn gluten, old process linseed oil meal, wheat middlings, and wheat bran with ground screenings not exceeding mill run. Oat meal, mill by-products, oat middlings, oat hulls, oat groats, 1 per cent salt. Contains not more than 10 per cent crude fiber and not less than 6 per cent fat and 25 per cent protein. Registered in 1919, and 1920.	Two official samples. One in accord with guaranty. The other in accord with guaranty in protein and fat; slightly high in fiber.
Fancy Broadflake. Sheffield King Milling Co., Minneapolis, Minn. Composed of wheat bran and ground wheat screenings. Contains not more than 12.75 per cent crude fiber and not less than 3.5 per cent fat and 13.5 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Farmers' Union Ready Ration. Farmers' Union Grain & Supply Co., Waterville, Me. Composed of distillers' grain, cottonseed meal, linseed oil meal, gluten feed, hominy meal, wheat bran, barley, malt sprouts, brewers' grains and salt. Contains not more than 10 per cent crude fiber and not less than 6 per cent fat and 25 per cent protein. Registered in 1919 and 1920.	Two official samples. In accord with guaranty.
Farmers' Union Stock Feed. Farmers' Union Grain & Supply Co., Waterville, Me. Composed of corn meal, hominy, brewers' grains, oatmeal, mill by-products (oat hulls, oat middlings, oat shorts), salt. Contains not more than 11 per cent crude fiber and not less than 3.5 per cent fat and 11 per cent protein.	One official sample. In accord with guaranty in fat and protein; high in fiber.
Fidelity Stock Feed. Nowak Milling Co., Buffalo, N. Y. Composed of ground oats, corn feed meal, hominy feed, wheat middlings, oat hulls, salt ½ of 1 per cent. Contains not more than 12 per cent crude fiber and not less than 3 per cent fat and 8 per cent protein.	One official sample. In accord with guranty in protein and fat; slightly high in fiber.
Fourex Dairy Ration. The Ubiko Milling Co., Cincinnati, Ohio. Composed of cottonseed meal, old process linseed meal, hominy feed, wheat bran and middlings, gluten feed, reground oat feed, (oat hulls, oat shorts, oat middlings), rye middlings, malt sprouts and salt. Contains not more than 12 per cent crude fiber and not less than 4 per cent fat and 20 per cent protein. Registered in 1919 and 1920.	Two official samples. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Go-Tu-It Hog Ration. The Park & Pollard Co., Boston, Mass. Composed of cocoanut oil meal, velvet bean meal, peanut oil meal, rice bran, old process linseed oil meal, alfalfa meal, hominy meal, oat hulls, oat middlings, oat shorts, ground barley, fish, meat, bone corn meal, corn germ meal, wheat middlings, salt, calcium carbonate. Contains not more than 13 per cent crude fiber and not less than 6 per cent fat and 15 per cent protein. Registered in 1919 and 1920.	Two official samples. One in accord with guaranty. The other in accord with guaranty in protein and fiber; low in fat.
Gold Mine Feed. Sheffield & King Milling Co., Minneapolis, Minn. Composed of bran, shorts, low grade flour, wheat produce and pulverized wheat screenings. Contains not more than 9.3 per cent crude fiber and not less than 4.5 per cent fat and 15 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Grandin's Twin Six Dairy Feed. D. H. Grandin Milling Co., Jamestown, N. Y. Composed of linseed oil meal, cottonseed meal, corn gluten feed, rice bran, wheat bran, wheat middlings, alfalfa meal, hominy feed, corn feed meal, wheat middlings with palm oil, red dog flour and a small percentage of salt. Contains not more than 13.5 per cent crude fiber and not less than 5 per cent fat and 22 per cent protein. Registered in 1919.	Two official samples. In accord with guaranty.
Grandin's Stock Feed. D. H. Grandin Milling Co., Jamestown, N. Y. Composed of ground corn, ground oats, ground barley, hominy feed, wheat middlings, oat meal mill by-products (oat middlings, oat hulls, oat shorts) and a small percentage of salt. (Wheat middlings may contain ground screenings not exceeding mill run). Contains not more than 14 per cent crude fiber and not less than 4 per cent fat and 10 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Hog Meal. Cornish Farmers' Union, Cornish, Me. Contains not more than 5 per cent crude fiber and not less than 4 per cent fat and 15 per cent protein. Registered in 1919. The guarantees as given are as sent in by the dealer. This feed was not registered at time of sale.	One dealer's sample. In accord with guaranty in protein; not examined for fiber and fat.
Holstein Feed. Indiana Milling Co., Terre Haute, Indiana. Composed of wheat bran with ground screenings not exceeding mill run, and cob meal. Contains not more than 16 per cent crude fiber and not less than 3 per cent fat and 12 per cent protein. Registered in 1919.	One official sample. In accord with guaranty in fat; slightly low in protein; slightly high in fiber.
International Climax Dairy Feed. International Sugar Feed Co., Minneapolis, Minn. Composed of cottonseed meal, molasses, ground clipped oat by-products, ground cleaned grain screenings, salt. Contains not more than 15 per cent crude fiber and not less than 4 per cent fat and 12.5 per cent protein. Registered in 1919 and 1920.	Two official samples. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
International Diamond Dairy Feed. International Sugar Feed Co., Minneapolis, Minn. Composed of corn gluten feed, wheat bran, old process oil meal, cottonseed meal, molasses, ground and bolted screenings from wheat, salt. Contains not more than 10 per cent crude fiber and not less than 5 per cent fat and 24 per cent protein. Registered in 1919 and 1920.	Two official samples. In accord with guaranty.
International Special Dairy Feed. International Sugar Feed Co., Minneapolis, Minn. Composed of old process oil meal, cottonseed meal, corn gluten feed, wheat bran, molasses, ground clipped oat by-product, salt. Ground cleaned grain screenings. Contains not more than 15 per cent crude fiber and not less than 4.5 per cent fat and 15 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Iowa Stock Feed. Purity Oats Co., Davenport, Iowa. Composed of wheat middlings, corn meal, hominy feed, brewers' dried grains, corn gluten feed, oat meal mill by-product (oat shorts, oat hulls, oat middlings) and 1 per cent table salt. Contains not more than 12.75 per cent crude fiber and not less than 4 per cent fat and 10 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Lactola Dairy Feed. Chapin & Co., Chicago, Ill. Composed of brewers' grains, cottonseed meal, corn gluten meal, yeast dried grains, copra (cocoanut oil) meal, ivory nut meal, molasses, salt. Contains not more than 12 per cent crude fiber and not less than 3 per cent fat and 16.5 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Larro Feed. The Larrowe Milling Co., Detroit, Mich. Composed of cottonseed meal, corn gluten feed, old process linseed oil meal, dried beet pulp, standard wheat bran, standard wheat middlings and ¾ of 1 per cent salt. Wheat bran and wheat middlings may contain ground screenings not exceeding mill run. Contains not more than 13.5 per cent crude fiber and not less than 5 per cent fat and 22 per cent protein. Registered in 1919 and 1920.	Two official samples. The 1919 sample low in protein and fat; in accord in fiber. The 1920 sample in accord with guaranty.
Loyal Stock Feed. Purity Oats Co., Davenport, Iowa. Composed of gluten, corn feed meal, hominy feed, oat meal mill by-product (oat shorts, oat hulls, oat middlings) and 1 per cent of salt. Contains not more than 14 per cent crude fiber and not less than 4 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.
Master Grain Ration. Clover Leaf Milling Co., Buffalo, N. Y. Composed of molasses, dried grains from barley, malt, and corn, wheat bran, standard middlings, linseed meal (old process), corn gluten feed, cocoanut oil meal (old process), cottonseed meal, and one-half of one per cent fine table salt. Contains not more than 10 per cent crude fiber and not less than 5 per cent fat and 24 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Mormilk Ready Ration Dairy Feed. Interstate Feed Association, Toledo, Ohio. Composed of cottonseed meal, old process oil meal, corn gluten feed, bran (wheat), toasted wheat feed, corn oil meal, hominy feed, wheat middlings. Contains not more than 10 per cent crude fiber and not less than 6 per cent fat and 25 per cent protein.	One official sample. In accord with guaranty in fat; slightly low in protein; slightly high in fiber.
Morris Special Dairy Feed. Morris Bros., Oneonta, N. Y. Composed of cottonseed meal, linseed oil meal, corn gluten feed, hominy or corn meal, wheat bran, salt. Contains not more than 9.5 per cent crude fiber and not less than 5 per cent fat and 24 per cent protein.	One official sample. In accord with guaranty.
National Stock Feed. Stratton-Ladish Milling Co., Toledo, Ohio. Composed of cottonseed meal, oat meal mill by-products (oat middlings, oat hulls, oat shorts), corn feed meal, salt. Contains not more than 12 per cent crude fiber and not less than 3 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty in fat; slightly low in protein; slightly high in fiber.
Nu Life Balanced Ration. Fred L. Cressey, Boston, Mass. Composed of beet pulp, gluten, cottonseed meal, ground oats, cocoanut oil meal, wheat bran, oil meal, wheat middlings, ground barley, corn feed meal and salt. Contains not more than 10 per cent crude fiber and not less than 4 per cent fat and 22 per cent protein. Registered in 1919 and 1920.	Two official samples. One in accord with guaranty in protein; not examined for fiber and fat. The other in accord with guaranty in fiber and fat; low in protein.
Nu Life Stock Feed. Fred L. Cressey, Boston, Mass. Composed of white hominy, oat feed and salt. Contains not more than 16 per cent crude fiber and not less than 2 per cent fat and 7.5 per cent protein.	One official sample. In accord with guaranty.
Old Honesty Stock Feed. Oswego Milling Co., Oswego, N. Y. Composed of hominy feed, corn meal, oat hulls, oat shorts, oat middlings, oil meal, cottonseed meal, wheat bran and salt. Ground barley and oats. Contains not more than 12 per cent crude fiber and not less than 3 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty in fat and protein; high in fiber.
O-Ne-On-Ta Dairy Ration. Elmore Milling Co., Oneonta, N. Y. Composed of corn gluten feed, wheat bran, old process oil meal, pure ground oats, hominy, cottonseed meal, ½ of 1 per cent salt. Contains not more than 10 per cent crude fiber and not less than 5 per cent fat and 22 per cent protein.	One official sample. In accord with guaranty.
Orono Dairy Feed. J. B. Ham Co., Lewiston, Me. Composed of wheat bran, hominy, gluten feed, linseed oil meal, cottonseed meal, distillers' grains and salt. Contains not more than 10 per cent crude fiber and not less than 5 per cent fat and 22 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Osota Feed. National Milling Co., Toledo, Ohio. Composed of bran wheat and wheat middlings with ground screenings not exceeding mill run. Contains not more than 10 per cent crude fiber and not less than 4.5 per cent fat and 15 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Park & Pollard Stock Feed. Park & Pollard Co., Boston, Mass. Composed of ground corn, hominy feed, oat hulls, oat middlings, oat shorts, old process linseed meal, calcium carbonate and salt. Contains not more than 12 per cent crude fiber and not less than 1½ per cent fat and 9 per cent protein. Registered in 1919 and 1920.	Four official samples. Three in accord with guaranty. The other in accord with guaranty in protein and fat; high in fiber.
Paragon Dairy Feed. Chas. M. Cox Co., Boston, Mass. Composed of cottonseed meal, linseed meal, bran, distillers' grains, gluten feed, copra meal, barley mill run screenings, oat feed (oat middlings, oat shorts, oat hulls) and not over 1 per cent salt. Contains not more than 14 per cent crude fiber and not less than 4 per cent fat and 22 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Peerless Dairy Feed. Fuller Holway Co., Augusta, Maine. Composed of barley malt, rye malt, malt sprouts, corn meal, cottonseed meal, wheat middlings, ground oats, 1 per cent salt. Contains not more than 15.5 per cent crude fiber and not less than 5.3 per cent fat and 17 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Peerless Stock Feed. E. A. Clark Co., Portland, Me. Composed of corn feed meal, wheat bran, middlings, hominy feed, oat feed, oat hulls, oat middlings and salt. Contains not more than 10 per cent crude fiber and not less than 3.5 per cent fat and 9 per cent protein. Registered in 1919.	One official sample. Somewhat low in protein and fat; high in fiber.
Portage Stock Feed. The Akron Feed & Milling Co., Akron, Ohio. Composed of either white or yellow shelled corn, barley, oat shorts, oat hulls, wheat middlings, oat middlings and ½ of one per cent of salt. Contains not more than 10 per cent crude fiber and not less than 4 per cent fat and 8½ per cent protein. Registered in 1919.	One official sample. One dealer's sample. Both samples much higher in protein and fiber and lower in fat than guaranty. Guaranty has little relation to composition as found.
Purina Calf Chow. Ralston Purina Co., St. Louis, Mo. Composed of blood flour, linseed meal, hominy feed, wheat flour, yellow corn feed meal and 1 per cent salt. Contains not more than 4.5 per cent crude fiber and not less than 3.2 per cent fat and 27 per cent protein.	One official sample. In accord with guaranty.
Quarto Dairy Feed. G. E. Patterson & Co., Memphis, Tenn. Composed of alfalfa, cottonseed meal, velvet bean and pod meal and molasses. Contains not more than 15 per cent crude fiber and not less than 3.5 per cent fat and 24 per cent protein. Registered in 1919.	One dealer's sample. In accord with guaranty in protein and fat; high in fiber.
Ryde's Cream Calf Meal. Ryde & Co., Chicago, Ill. Composed of ground flaxseed, wheat flour, locust bean meal, recleaned cottonseed meal, blood flour, beans and lentils, cocoa shell meal, hominy feed, Fenugreek, anise and salt. Contains not more than 6 per cent crude fiber and not less than 5 per cent fat and 25 per cent protein. Registered in 1919.	One official sample. In accord with guaranty in fat; low in protein and slightly high in fiber.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Schumacher Calf Meal. The Quaker Oats Co., Chicago, Ill. Composed of oatmeal, wheat meal, ground flaxseed, milk albumen, old process linseed oil meal, blood meal, ½ of 1 per cent bicarbonate of sôda. Contains not more than 4 per cent crude fiber and not less than 8 per cent fat and 18 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Stevens 44 Dairy Ration. The Park & Pollard Co., Boston, Mass. Composed of linseed oil meal, cottonseed meal, wheat bran with mill run of screenings, corn gluten feed, cocoanut oil meal, pea meal, brewers' dried grains, ground barley, wheat middlings, hominy meal, corn germ meal, buckwheat, middlings, corn meal, salt. Contains not more than 14 per cent crude fiber and not less than 5 per cent fat and 24 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Stock Feed. J. J. Lappin & Co., Portland, Me. Contains not more than 18 per cent crude fiber and not less than 4 per cent fat and 10 per cent protein. The guarantees as given are as sent in by the dealer. This feed was not registered at time of sale.	One dealer's sample. Slightly low in protein. Not examined for fiber and fat.
Sunbeam Dairy Ration. The Ubiko Milling Co., Cincinnati, Ohio. Composed of cottonseed meal, old process linseed meal, corn gluten feed, dried beet pulp, wheat bran, wheat middlings, hominy meal, salt. Contains not more than 12 per cent crude fiber and not less than 3 per cent fat and 20 per cent protein.	One official sample. In accord with guaranty.
Superior Stock Feed. Interstate Feed Association, Toledo, Ohio. Composed of fine white hominy feed and reground oat feed. Contains not more than 18 per cent crude fiber and not less than 4 per cent fat and 10 per cent protein.	Slightly low in fat and protein; slightly high in fiber.
Syragold Milk Ration. Syracuse Milling Co., Syracuse, N. Y. Composed of dried brewers' grains, malt sprouts, corn gluten feed, linseed meal, wheat bran with mill run screenings, cottonseed meal, ground cottonseed hulls and salt. Contains not more than 15 per cent crude fiber and not less than 4 per cent fat and 20 per cent protein. Registered in 1919.	One official sample. In accord with guaranty in protein and fat; high in fiber.
Towles Balanced Ration. J. N. Towle & Co., Bangor, Me. Composed of wheat bran, cottonseed meal, old process linseed meal, hominy meal, corn meal, gluten feed, salt. Contains not more than 9.13 per cent crude fiber and not less than 5.72 per cent fat and 22.13 per cent protein. Registered in 1919.	One official sample. In accord with guaranty in protein and fiber; slightly low in fat.
Towles Pig Feed. J. N. Towle & Co., Bangor, Me. Composed of wheat bran, wheat middlings, old process linseed meal, hominy meal, corn meal, meat meal. Contains not more than 7.22 per cent crude fiber and not less than 6 per cent fat and 18 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Triangle Dairy Feed. Chapin & Co., Chicago, Ill. Composed of linseed meal, cottonseed meal, gluten feed, corn germ meal, copra meal, hominy meal, oat meal mill by-products (oat meal middlings, oat hulls, oat shorts) ground barley, salt. Contains not more than 12 per cent crude fiber and not less than 4 per cent fat and 21 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
True Value Dairy Feed. Stratton-Ladish Mlg. Co., Milwaukee, Wis. Composed of cottonseed meal, linseed meal, corn gluten feed, ground oats, hominy feed, copra meal, ground corn (cocoanut oil meal) wheat bran, wheat middlings, with ground screenings not exceeding mill run, salt. Contains not more than 10 per cent crude fiber and not less than 5 per cent fat and 24 per cent protein.	One official sample. In accord with guaranty.
True Value Stock Feed. Stratton-Ladish Mlg. Co., Milwaukee, Wis. Composed of cottonseed meal, hominy feed, ground oats, ground corn, oat meal mill by-products (oat middlings, oat hulls, oat shorts) salt. Contains not more than 12 per cent crude fiber and not less than 3.5 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty in fat and protein; high in fiber.
Ubiko Pig Meal. The Ubiko Milling Co., Cincinati, Ohio. Composed of digester tankage, wheat middlings, hominy feed, cocoanut oil meal, germ oil meal, old process linseed meal, rye middlings, and salt. Contains not more than 8 per cent crude fiber and not less than 5 per cent fat and 18 per cent protein. Registered in 1919 and 1920.	Two official samples. In accord with guaranty.
Unicorn Dairy Ration. Chapin & Co., Chicago, Ill. Composed of cottonseed meal, linseed meal, corn gluten feed, corn oil meal, brewers' grains, wheat bran with mill run screenings, hominy meal, corn gluten meal, salt. Contains not more than 10 per cent crude fiber and not less than 4.5 per cent fat and 26 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Union Grains Biles Ready Ration. The Ubiko Milling Co., Cincinnati, Ohio. Composed of fourex corn distillers' dried grains, choice cottonseed meal, old process linseed meal, white wheat middlings, winter wheat bran, hominy meal, cocoanut oil meal, corn gluten feed, brewers' dried grains, barley malt sprouts, and one-half per cent of fine table salt. Registered in 1919 and 1920.	Two official samples. In accord with guaranty.
Vitality Dairy Feed. Rosenbaum Bros., Chicago, Ill. Composed of old process linseed oil meal, corn gluten feed, corn feed meal, wheat bran, wheat middlings, cottonseed meal, ground oats, ground barley and salt. Contains not more than 9 per cent crude fiber and not less than 4 per cent fat and 20 per cent protein.	One official sample. In accord with guaranty.
Voights Cow Feed. Voights Milling Co., Grand Rapids, Mich. Composed of bran and middlings and screenings as run from mill. Contains not more than 10 per cent crude fiber and not less than 3.5 per cent fat and 14.5 per cent protein.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Wirthmore Balanced Ration. Chas. M. Cox Co., Boston, Mass. Composed of cottonseed meal, linseed meal, corn gluten feed, fancy distillers' grains, wheat bran, choice yeast grains, hominy or corn meal, and not over ¼ of 1 per cent salt. Contains not more than 9.5 per cent crude fiber and not less than 5 per cent fat and 25 per cent protein. Registered in 1919 and 1920.	Two official samples. One in accord with guaranty in protein; not examined for fiber and fat. The other in accord with guaranty in fat and protein; high in fiber.
Wirthmore Hog Feed. Chas. M. Cox Co., Boston, Mass. Composed of tankage, wheat middlings, hominy, corn meal, linseed meal, peanut feed, corn feed meal, red dog flour, and about ½ of 1 per cent salt. Contains not more than 7 per cent crude fiber and not less than 6 per cent fat and 17 per cent protein.	One official sample. In accord with guaranty.
Wirthmore Pig Feed. Chas. M. Cox., Boston, Mass. Composed of tankage, edible bone meal, peanut feed, wheat middlings, wheat bran, linseed meal, ground alfalfa, ground hominy, corn meal and about ½ of 1 per cent salt. Contains not more than 14 per cent crude fiber and not less than 5 per cent fat and 1[illegible] per cent protein.	One official sample. In accord with guaranty.
Wirthmore Stock Feed. Chas. M. Cox Co., Boston, Mass. Composed of ground barley, ground oats, ground hominy meal, ground corn, oa meal, mill by-products (oat middlings, oat shorts, oat hulls) and ½ of 1 per cent salt. Part of the ingredients having been cooked or steamed and more easily assimulated than raw grains and have better keeping qualities. Contains not more than 9.5 per cent crude fiber and not less than 4 per cent fat and 9 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Zenith Stock Feed. E. Crosby & Co., Brattleboro, Vt. Composed of corn, homlik (corn feed meal) hominy feed, oat feed, oat hulls, oat middlings. Contains not more than 13 per cent crude fiber and not less than 3.25 per cent fat and 8.5 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

COMPOUNDED FEEDS FOR POULTRY.

Aunt Mary's Laying Mash. Oswego Milling Co., Oswego, N. Y. Composed of ground corn, wheat, oats, barley, kaffir corn, buckwheat, alfalfa, fish, meat, bone, wheat bran and middlings with mill run of screenings, calcium carbonate and salt. Contains not more than 12 per cent crude fiber and not less than 1.5 per cent fat and 18 per cent protein.	One official sample. In accord with guaranty.
Baby Buster Chick Feed. The Park & Pollard Co., Boston, Mass. Composed of cracked: corn, wheat, kaffir corn, milo, oats, whole millet seed and shredded fish. Contains not more than 5 per cent crude fiber and not less than 2 per cent fat and 11 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Badger Laying Mash. Chas. A. Krause Mlg. Co., Milwaukee, Wis. Composed of wheat bran, wheat middlings with ground screenings not exceeding mill run, maize, red dog flour, corn feed meal, alfalfa meal, meat scraps, corn germ meal and hominy feed. Contains not more than 10 per cent crude fiber and not less than 3.5 per cent fat and 18 per cent protein. Registered in 1919 and 1920.	Two official samples. In accord with guaranty.
Dirigo Egg Mash. Oscar Holway Co., Auburn, Me. Composed of alfalfa meal, bran, middlings, wheat meal, corn feed meal, ground corn, linseed meal, meat scraps, salt ½ of 1 per cent. Contains not more than 10 per cent crude fiber and not less than 3 per cent fat and 16 per cent protein.	One official sample. In accord with guaranty.
Dirigo Intermediate Chick Feed. Oscar Holway Co., Auburn, Me. Composed of corn, wheat, kaffir corn, hulled oats, buckwheat and millet. Contains not more than 5 per cent crude fiber and not less than 2.5 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.
Dow's Favorite Poultry Meal. John C. Dow Co., Boston, Mass. Composed of dried meat, bone, Foenugreek seed and cottonseed meal. Contains not more than 0 per cent crude fiber and not less than 10 per cent fat and 30 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Dry Feed. J. N. Towle & Co., Bangor, Me Composed of wheat bran, wheat middlings, corn meal, meat scraps, old process linseed meal. Contains not more than 0 per cent crude fiber and not less than 10 per cent fat and 20 per cent protein. Registered in 1919.	One official sample. Not guaranteed for fiber; low in fat.
Dry Mash. J. B. Ham Co., Lewiston, Me. Composed of corn meal, ground oats, wheat bran, wheat middlings, linseed meal, meat scraps, charcoal and alfalfa. Contains not more than 12 per cent crude fiber and not less than 3.5 per cent fat and 15 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Elm City Laying Mash. Merrill & Mayo Co., Waterville, Me. Composed of wheat bran, wheat middlings, alfalfa, meal, corn bran, corn feed meal, linseed oil meal, meat scraps, ½ of 1 per cent salt. Contains not more than 10 per cent crude fiber and not less than 3 per cent fat and 15 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Elmore Egg Mash. Elmore Milling Co., Oneonta, N. Y. Composed of corn meal, rollled oats, ground barley, wheat flour middlings, wheat bran, hominy feed, corn gluten feed, alfalfa meal, old process oil meal, meat and bone meal, salt. Contains not more than 8 per cent crude fiber and not less than 4 per cent fat and 18 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Farmers' Union Chick Feed. Farmers' Union Grain & Supply Co., Waterville, Me. Composed of millet seed, cracked wheat, cracked kaffir corn, oat meal, cracked corn. Contains not more than 3.5 per cent crude fiber and not less than 3.5 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Farmers' Union Egg Mash. Farmers' Union Grain & Supply Co., Waterville, Me. Composed of corn meal, rolled oats, ground barley, wheat flour, middlings, hominy feed, wheat bran, meat and bone meal, corn gluten feed, alfalfa meal, old process oil meal, salt. Contains not more than 8 per cent crude fiber and not less than 4 per cent fat and 18 per cent protein.	One official sample. In accord with guaranty.
Farmers' Union Growing Mash. Farmers' Union Grain & Supply Co., Waterville, Me. Composed of rolled oats, corn gluten feed, old process oil meal, corn meal, wheat middlings, wheat bran, bone meal, salt. Contains not more than 8 per cent crude fiber and not less than 4 per cent fat and 17 per cent protein.	One official sample. In accord with guaranty.
Ful-O-Pep Dry Mash. The Quaker Oats Co., Chicago, Ill. Composed of meat scraps, fish meal, oat meal, alfalfa meal, wheat bran (with ground screenings not exceeding mill run) hominy feed, yellow hominy feed, corn gluten feed, ground grain screenings, bone meal, cottonseed meal. Contains not more than 10 per cent crude fiber and not less than 4 per cent fat and 20 per cent protein.	One official sample. In accord with guaranty.
Ful-O-Pep Growing Mash. The Quaker Oats Co., Chicago, Ill. Composed of meat scraps, oatmeal, fish meal, corn gluten feed, hominy feed, yellow hominy feed, wheat bran (with ground screenings not exceeding mill run) alfalfa meal, bone meal, ground puffed wheat, ground corn puffs. Contains not more than 9 per cent crude fiber and not less than 5.25 per cent fat and 17 per cent protein.	One official sample. In accord with guaranty.
Globe Egg Mash. The Albert Dickinson Co., Chicago, Ill. Composed of wheat bran, wheat middlings, alfalfa meal, ground corn bran, corn feed meal, linseed oil cake, meat scraps. Contains not more than 10 per cent crude fiber and not less than 3 per cent fat and 15 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Grandin's Poultry Dry Mash. D. H. Grandin Milling Co., Jamestown, N. Y. Composed of ground: fish, meat, bone, powdered buttermilk, corn, wheat, oats, barley, kaffir corn, milo maize, buckwheat, alfalfa, calcium carbonate, wheat bran, wheat middlings, linseed oil meal, corn gluten feed and salt. (Bran and middlings may contain ground screenings not exceeding mill run). Contains not more than 10 per cent crude fiber and not less than 3 per cent fat and 20 per cent protein.	One official sample. Low in protein; slightly high in fiber; in accord in fat.
Growing Feed. The Park & Pollard Co., Boston, Mass. Composed of ground: corn, wheat, wheat screenings, oats, barley, kaffir corn, buckwheat, alfalfa, meat bone, wheat bran with mill run of screenings, wheat middlings, calcium carbonate and salt. Contains not more than 8 per cent crude fiber and not less than 1.5 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Iroquois Chick Feed. Buffalo Cereal Co., Buffalo, N. Y. Composed of cracked corn, wheat, kaffir corn, peas, millet and oat groats. Contains not more than 2 per cent crude fiber and not less than 2 per cent fat and 12 per cent protein.	One official sample. In accord with guaranty in fiber and fat; slightly low in protein.
Lay or Bust Dry Mash. The Park & Pollard Co., Boston, Mass. Composed of ground: corn, wheat, oats, barley, kaffir corn, buckwheat, alfalfa, fish, meat bone and wheat bran with mill run of screenings, wheat middlings, calcium carbonate and salt. Contains not more than 12 per cent crude fiber and not less than 1.5 per cent fat and 18 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Maxims Dry Mash. D. H. Maxim Estate, Winthrop, Me. Composed of corn meal, ground oats, wheat bran, wheat middlings, gluten oil meal, alfalfa, cottonseed meal, meat meal. Contains not more than 12 per cent crude fiber and not less than 4.5 per cent fat and 18 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Monarch Poultry Mash. F. H. Brastow & Son, So. Brewer, Me. Composed of wheat bran, wheat middlings, gluten feed, beef scraps, alfalfa and corn meal. Contains not more than 7 per cent crude fiber and not less than 5.5 per cent fat and 20 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Nu-Life Dry Mash. Fred L. Cressey, Boston, Mass. Composed of rolled oatmeal, fish scrap, beef scrap, oil meal, cottonseed, gluten, meat bone meal, ground oats, middlings, bran, beet pulp, corn feed meal and salt. Contains not more than 8 per cent crude fiber and not less than 4 per cent fat and 20 per cent protein.	One official sample. In accord with guaranty.
Peerless Baby Chick Feed. E. A. Clark & Co., Portland, Me. Composed of cracked wheat, hulled oats, cracked kaffir, cracked corn, and millet seed. Contains not more than 5 per cent crude fiber and not less than 3 per cent fat and 12 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Peerless Milk Ration. Clover Leaf Milling Co., Buffalo, N. Y. Composed of cottonseed meal, pure old process linseed meal, cocoanut oil meal, corn gluten feed, wheat bran, dried grains from barley malt and corn, cleaned ground and bolted grain screenings, ground and bolted clipped oat by-product, molasses and one-half of 1 per cent fine table salt. Contains not more than 12 per cent crude fiber and not less than 5 per cent fat and 20 per cent protein.	One official sample. In accord with guaranty in protein and fat; slightly high in fiber.
Purina Chicken Chowder. Ralston Purina Co., St. Louis, Mo. Composed of wheat middlings, wheat bran, gluten feed from corn, corn meal, alfalfa flour, linseed flour, granulated meat, charcoal not over 1 per cent and salt. Contains not more than 11 per cent crude fiber and not less than 4 per cent fat and 19 per cent protein.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Red Ribbon Chick Feed. The Park & Pollard Co., Boston, Mass. Composed of cracked: corn, wheat, oats, kaffir corn, milo and whole millet seed. Contains not more than 5 per cent crude fiber and not less than 2 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.
Schumacher Feed. The Quaker Oats Co., Chicago, Ill. Composed of ground corn, hominy feed, yellow hominy feed, linseed oil meal, ground barley, wheat middlings, (with ground screenings not exceeding mill run) cottonseed meal, oatmeal mill by-product (oat middlings, oat hulls, oat shorts), ground puffed rice, ground puffed wheat, calcium phosphate, ½ of 1 per cent salt, rye flour. Contains not more than 10 per cent crude fiber and not less than 3.25 per cent fat and 10 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Schumacher Little Chick Feed with Grit. The Quaker Oats Co., Chicago, Ill. Composed of cracked wheat, cracked kaffir and milo, cracked Indian corn, whole millet seed, oatmeal, 6% marble grit, charcoal, wild buckwheat (with not exceeding ½ of 1 per cent miscellaneous wild seeds occurring in above seeds and grains). Contains not more than 5 per cent crude fiber and not less than 2.5 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.
Small's Dry Mash. S. L. Small, Dexter, Me. Composed of bran, middlings, corn meal, gluten feed, meat scraps, alfalfa meal. Contains not more than 9 per cent crude fiber and not less than 4 per cent fat and 20 per cent protein.	One official sample. In accord with guaranty.
Tom Boy Chick Feed. Purity Oats Co., Davenport, Iowa. Composed of cracked: corn, wheat, kaffir corn or milo maize, steel cut oats, recleaned wheat screenings and millet. Contains not more than 5 per cent crude fiber and not less than 3 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.
Tom Boy Poultry Mash. Purity Oats Co., Davenport, Iowa. Composed of ground: meat, wheat, oat meal, wheat middlings, milo maize, buckwheat, cornmeal, barley, oat middlings, millet, gluten feed, kaffir corn, alfalfa meal, hominy feed, wheat bran, oat germ meal, rock phosphate, salt, calcium carbonate, and charcoal. Contains not more than 10 per cent crude fiber and not less than 4 per cent fat and 15 per cent protein.	One official sample. In accord with guaranty.
True Value Chick Developer. Stratton-Ladish Mlg. Co., Milwaukee, Wis. Composed of cracked: corn, wheat, kaffir corn, or milo maize seed, millet seed, oat groats. Contains not more than 5 per cent crude fiber and not less than 2.5 per cent fat and 10 per cent protein.	Two official samples. In accord with guaranty.
True Value Poultry Mash. Stratton-Ladish Milling Co., Milwaukee, Wis. Composed of wheat bran, wheat middlings, with ground screenings not exceeding mill run, corn feed meal, alfalfa meal, corn gluten feed, ground oats, meat scraps, linseed oil meal, salt. Contains not more than 8 per cent crude fiber and not less than 4 per cent fat and 18 per cent protein.	One official sample. In accord with guaranty in protein and fat; high in fiber.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Ubiko Buttermilk Growing Mash. The Ubiko Milling Co., St. Bernard, Ohio. Composed of meat meal, bone meal, corn meal, wheat bran and middlings, whole ground oats, ground barley, old process linseed meal, and dried buttermilk. Contains not more than 6 per cent crude fiber and not less than 3 per cent fat and 15 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Wirthmore Buttermilk Baby Chick Food. Chas. M. Cox Co., Boston, Mass. Composed of dried buttermilk, dried milk albumen, fine ground oats, bone meal, white corn, hominy feed and wheat middlings. Contains not more than 5 per cent crude fiber and not less than 5 per cent fat and 13.5 per cent protein.	One official sample. In accord with guaranty.
Wirthmore Gritless Chick Feed. Chas. M. Cox Co., Boston, Mass. Composed of cracked wheat, yellow corn, peas, kaffir corn, milo maize, white corn and hulled oats. Contains not more than 3.5 per cent crude fiber and not less than 3 per cent fat and 11 per cent protein.	Two official samples. In accord with guaranty.

COMPOUNDED FEEDS FOR POULTRY—SCRATCH FEEDS.

Aunt Mary's Scratch Feed. Oswego Milling Co., Oswego, N. Y. Composed of wheat, barley, milo, kaffir corn, buckwheat, cracked corn and oats. Contains not more than 5 per cent crude fiber and not less than 1.5 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.
Dirigo Scratch Feed. Oscar Holway Co., Auburn, Me. Composed of wheat, kaffir corn, barley, cracked Indian corn, buckwheat, and sunflower seed. Contains not more than 5 per cent crude fiber and not less than 2.5 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.
Elm City Scratch Feed. Merrill & Mayo Co., Waterville, Me. Composed of wheat, cracked corn, kaffir corn, milo maize, barley, buckwheat and sunflower seed. Contains not more than 5 per cent crude fiber and not less than 2.5 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.
Farmers' Union Fancy Scratch Feed. Farmers' Union Grain & Supply Co., Waterville, Me. Composed of wheat, cracked corn, barley, buckwheat, kaffir corn, sunflower seed. Contains not more than 5 per cent crude fiber and not less than 3.5 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.
Grandin's Scratch Feed. D. H. Grandin Mlg. Co., Jamestown, N. Y. Composed of wheat, cracked corn, kaffir corn, milo maize, barley, buckwheat and sunflower seed. Contains not more than 5 per cent crude fiber and not less than 2.5 per cent fat and 10 per cent protein. Registered in 1919.	One official sample. In accord with guaranty in fat and protein; slightly high in fiber.
Krause Scratch Feed. Chas. A. Krause Mlg. Co., Milwaukee, Wis. Composed of wheat, corn, kaffir corn or milo maize, barley, oats, buckwheat and sunflower seed. Contains not more than 5 per cent crude fiber and not less than 2.5 per cent fat and 9 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Marathon Scratch Feed. Nowak Milling Corporation, Buffalo, N. Y. Composed of wheat, milo maize, cracked corn, barley and buckwheat. Contains not more than 5 per cent crude fiber and not less than 3 per cent fat and 10 per cent protein. Registered in 1919.	Two official samples. In accord with guaranty.
Nu Life Scratch Feed. Fred L. Cressey, Boston, Mass. Composed of kaffir corn, buckwheat, barley, cracked corn, oats and wheat. Contains not more than 7 per cent crude fiber and not less than 4 per cent fat and 9 per cent protein. Registered in 1919 and 1920.	Two official samples. One in accord with guaranty. The other in accord with guaranty in fiber and protein; low in fat.
Over the Top Scratch Feed. The Park & Pollard Co., Boston, Mass. Composed of cracked corn, wheat, buckwheat. barley, oats, kaffir corn, and milo. Contains not more than 5 per cent crude fiber and not less than 1.5 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.
Peerless Screened Scratch Feed. E. A. Clark & Co., Portland, Me. Composed of cracked corn, wheat, oats, buckwheat, barley, kaffir and sunflower seed. Contains not more than 5 per cent crude fiber and not less than 3 per cent fat and 10 per cent protein. Registered in 1919.	One official sample. Examined for protein only and in accord with guaranty.
Pontiac Scratch Feed. The Park & Pollard Co. Boston, Mass. Composed of cracked: corn, wheat, barley, buckwheat, oats, kaffir corn and milo. Contains not more than 5 per cent crude fiber and not less than 1.5 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.
Portage Scratch Feed. The Akron Feed & Milling Co., Akron, Ohio. Composed of corn wheat, barley, kaffir corn, sunflower seed and buckwheat. Contains not more than 3 per cent crude fiber and not less than 2.5 per cent fat and 9 per cent protein.	One official sample. In accord with guaranty.
Purina Scratch Feed. Ralston Purina Co., St. Louis, Mo. Composed of wheat, corn, barley, kaffir, milo, buckwheat and sunflower seed. Contains not more than 4 per cent crude fiber and not less than 2.5 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.
Red Ribbon Scratch Feed. The Park & Pollard Co., Boston, Mass. Composed of cracked corn, wheat, buckwheat, barley, oats, kaffir corn and milo. Contains not more than 5 per cent crude fiber and not less than 1.5 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.
Schumacher Scratch Grains. The Quaker Oats Co., Chicago, Ill. Composed of whole wheat, whole kaffir and milo, whole barley, cracked Indian corn, whole buckwheat, sunflower seeds. Contains not more than 5 per cent crude fiber and not less than 2.5 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.
Small's Scratch Feed. S. L. Small, Dexter, Me. Composed of cracked corn, oats and wheat. Contains not more than 5 per cent crude fiber and not less than 3 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Tom Boy Scratch Feed. Purity Oats Co., Davenport, Iowa. Composed of cracked corn, wheat, hulled oats, kaffir corn, or milo maize, barley, buckwheat and sunflower seed. Contains not more than 5 per cent crude fiber and not less than 3 per cent fat and 10 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
True Value Scratch Feed. Stratton-Ladish Mlg. Co., Milwaukee, Wis. Composed of cracked corn, wheat, barley, kaffir corn or milo maize, buckwheat, sunflower seed. Contains not more than 5 per cent crude fiber and not less than 2.5 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty.
Wirthmore Scratch Feed. Chas. M. Cox Co., Boston, Mass. Composed of wheat, kaffir corn, sunflower seed, buckwheat, barley, oats, cracked corn and milo maize. Contains not more than 5 per cent crude fiber and not less than 3 per cent fat and 11 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

CORN AND OATS GROUND TOGETHER.

Corn & Oat Chop. J. B. Ham Co., Lewiston, Me. Composed of corn and oats. Contains not more than 5 per cent crude fiber and not less than 4 per cent fat and 10 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Corn & Oat Chop. Merrill & Mayo Co., Waterville, Me. Contains not more than 6 per cent crude fiber and not less than 5 per cent fat and 10 per cent protein. Registered in 1919.	One official sample. In accord with guaranty in protein; slightly high in fiber; slightly low in fat.
Corn & Oat Chop. Stratton-Ladish Milling Co., Milwaukee, Wis. Contains not more than 9 per cent crude fiber and not less than 3.5 per cent fat and 9.5 per cent protein.	One official sample. In accord with guaranty.
Corn & Oat Feed. Eastern Grain Co., Bangor, Me. Contains not more than 6 per cent crude fiber and not less than 5 per cent fat and 10 per cent protein. Registered in 1919.	Two official samples. One sample high in fiber; low in fat; in accord with protein. The other sample in accord with guaranty.
Farmers' Union Corn & Oat Feed. Farmers' Union Grain & Supply Co., Waterville, Me. Composed of 50 pounds of corn, 30 pounds of oats ground together. Contains not more than 6 per cent crude fiber and not less than 4 per cent fat and 10 per cent protein.	One official sample. In accord with guaranty in protein and fat; high in fiber.
Maxim's Corn & Oat Feed. D. H. Maxim Estate, Winthrop, Me. Contains not more than 8 per cent crude fiber and not less than 4 per cent fat and 9 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Monarch Ground Feed. F. H. Brastow & Son, So. Brewer, Me. Contains not more than 6 per cent crude fiber and not less than 5 per cent fat and 10 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Winner Chop Feed. David Stott Flour Mills, Detroit, Mich. Composed of corn, corn feed meal, oats, oat meal by-products (oat hulls and chaff) and salt. Contains not more than 10 per cent crude fiber and not less than 5 per cent fat and 8 per cent protein.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
CORN FEED MEAL.	
Corn Feed Meal. Chas. A. Krause Milling Co., Milwaukee, Wisconsin. Composed of yellow corn. Contains not more than 4.5 per cent crude fiber and not less than 5 per cent fat and 9.5 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
GLUTEN FEED AND GLUTEN MEAL. (Corn)	
Buffalo Corn Gluten Feed. Corn Products Ref. Co., New York City. Composed of corn gluten feed. Contains not more than 8.5 per cent crude fiber and not less than 1 per cent fat and 23 per cent protein. Registered in 1919 and 1920.	Two official samples. In accord with guaranty.
Diamond Corn Gluten Meal. Corn Products Ref. Co., New York City. Composed of corn gluten meal. Contains not more than 4 per cent crude fiber and not less than 1 per cent fat and 40 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Jenks Corn Gluten Feed. Huron Milling Co. Harbor Beach, Mich. Composed of by-product of corn starch with corn bran. Contains not more than 8 per cent crude fiber and not less than 3 per cent fat and 22 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Staley's Corn Gluten Feed. A. E. Staley Mfg Co., Decatur, Ill. Composed of corn gluten feed. Contains not more than 12 per cent crude fiber and not less than 2.5 per cent fat and 23 per cent protein. Registered in 1919.	One official sample. In acc with guaranty.
(CORN) HOMINY FEED MEAL.	
Badger Hominy Feed. Chas. A. Krause Milling Co., Milwaukee, Wisconsin. Composed of white corn. Contains not more than 5 per cent crude fiber and not less than 6 per cent fat and 10 per cent protein. Registered in 1919.	One official sample. In acc with guaranty in protein an fiber; low in fat
Hominy Feed. The Patent Cereals Co., Geneva, N. Y. Composed of corn. Contains not more than 5 per cent crude fiber and not less than 5 per cent fat and 10 per cent protein. Registered in 1919.	One official sample. In acc with guaranty.
Logan Hominy Feed. Snyder Milling Co., Chillicothe, Ohio. Composed of part of grain of corn ground to meal. Contains not more than 6 per cent crude fiber and not less than 7 per cent fat and 10 per cent protein.	One official sample. In accor with guaranty in protein and fiber; low in fat
Yellow Hominy Feed. Buffalo Cereal Co., Buffalo, N. Y. Contains not more than 5 per cent crude fiber and not less than 6 per cent fat and 10 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
DISTILLERS' AND BREWERS' GRAINS.	
Corly Dried Yeast Grains. The Corly Co. Contains not more than 22 per cent crude fiber and not less than 5 per cent fat and 16 per cent protein. Registered in 1919. The guarantees as given are from the inspector's slip. This feed was not registered at time of sale.	One official sample. In accord with guaranty in protein and fat; slightly high in fiber.
OIL CAKE MEALS—COCOANUT MEAL.	
P & G Copra Oil Meal. The Proctor & Gamble Mfg Co., Cincinnati, Ohio. Composed of dried cocoanut meal only. Contains not more than 12 per cent crude fiber and not less than 6 per cent fat and 20 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
OIL CAKE MEALS—COTTONSEED FEED.	
Cottonseed Meal (Confiscated). W. D. Hall Co. Contains not more than 14 per cent crude fiber and not less than 5.5 per cent fat and 19.5 per cent protein. Registered in 1919. The guarantees as given are from the Inspector's slip. No manufacturer's certificate received.	One dealer's sample. In accord with guaranty in protein; not examined for fiber and fat.
Cottonseed Feed. Merrill & Mayo Co., Waterville, Maine. Contains not more than 18.5 per cent crude fiber and not less than 5.5 per cent fat and 26 per cent protein.	One official sample. In accord with guaranty.
OIL CAKE MEALS—COTTONSEED MEAL.	
Buckeye Cottonseed Meal. The Buckeye Cotton Oil Co., Cincinnati, Ohio. Composed of cottonseed only. Contains not more than 14 per cent crude fiber and not less than 5 per cent fat and 36 per cent protein. Registered in 1919.	One official sample. Slightly low in protein; not examined for fiber and fat.
Danish Brand Cottonseed Meal. Humphrey Godwin Co., Memphis, Tenn. Made from pressed cottonseed. Contains not more than 15 per cent crude fiber and not less than 5 per cent fat and 36 per cent protein. Registered in 1919 and 1920.	Seven official samples. Three dealers' samples. One official sample examined complete in accord with guaranty. Other samples (official) in accord with protein guaranty. The 3 dealers' samples in accord in protein guaranty. Not examined for fiber and fat.
Dove Brand Cottonseed Meal. F. W. Brode & Co., Memphis, Tenn. Contains not more than 12 per cent crude fiber and not less than 6 per cent fat and 38.62 per cent protein.	One dealers' sample. In accord with guaranty in protein. Not examined for fiber and fat.
Good Cottonseed Meal. Cottonseed Products Co., Louisville, Ky. Composed of decorticated cottonseed. Contains not more than 14 per cent crude fiber and not less than 5 per cent fat and 36 per cent protein. Registered in 1919 and 1920.	Three official samples. One completely examined in accord with guaranty. The remaining 2 in accord with protein guaranty. Two dealers' samples. Both in accord with protein guaranty. Not examined for fiber and fat.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Hall Brand Good Cottonseed Meal. W. D. Hall Co., Atlanta, Ga. Made from Upland cottonseed only. Contains not more than 14 per cent of crude fiber and not less than 5.5 per cent of fat and 36 per cent of protein. Registered in 1919 and 1920.	Seven official samples. Two official samples adulterated. Two official samples slightly low in protein and high in fiber. One sample in accord with guaranty. Two official samples examined for protein only and in accord with the guaranatay. Eight dealers' samples. All examined for protein only. Two in accord with protein guaranty. Six below in protein guaranty.
Good Cottonseed Meal. Taylor Commission Co., Atlanta, Ga. Made from Upland cottonseed only. Contains not more than 14 per cent crude fiber and not less than 5.5 per cent fat and 36 per cent protein. Registered in 1919 and 1920.	Two official samples. One in accord with guaranty. One examined only for protein slightly below protein guaranty. One dealers' sample. Examined only for protein and below guaranty.
Jay Brand Cottonseed Meal. F. W. Brode & Co., Memphis, Tenn. Made of cottonseed meal and cottonseed hulls. Contains not more than 14 per cent crude fiber and not less than 5 per cent fat and 36 per cent protein. Registered in 1919 and 1920.	Seven dealers' samples. All samples examined for protein only. Five in accord with protein guaranty. Two slightly below protein guaranty.
Prime Cottonseed Meal. The Cottonseed Products Co., Louisville, Ky. Contains not more than 11 per cent crude fiber and not less than 7 per cent fat and 41 per cent protein.	One official sample. In accord with guaranty.
Puritan Cottonseed Meal. J. E. Soper Co., Boston, Mass. Contains not more than 15 per cent crude fiber and not less than 5 per cent fat and 36 per cent protein. Registered in 1919 and 1920.	Three official samples. All in accord with guaranty in protein; the one examined in accord in fiber and fat. One dealers' sample. In accord with protein guaranty. Not examined for fiber and fat.
St. Clair Brand Cottonseed Meal. East St. Louis Cotton Oil Co., National Stock Yards Ill. Composed of ground cottonseed. Contains not more than 16 per cent crude fiber and not less than 5 per cent fat and 36 per cent protein. Registered in 1919.	Two dealers' samples. Both examined for protein only and in accord with guaranty.
Upland Cottonseed Meal. The Park & Pollard Co., Boston, Mass. Contains not more than 15 per cent crude fiber and not less than 5 per cent fat and 36 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

OIL CAKE MEALS—LINSEED MEAL.

Amco Old Process Linseed Meal and Oil Process Screening Oil Feed. American Milling Co., Peoria, Ill. Composed of linseed meal and screenings oil feed. Contains not more than 10 per cent crude fiber and not less than 5 per cent fat and 30 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Argentine Brand Old Process Ground Linseed Cake. Midland Linseed Products Co., Minneapolis, Minn. Composed of flaxseed only. Contains not more than 9.5 per cent crude fiber and not less than 6 per cent fat and 32 per cent protein.	One official sample. In accord with guaranty in fat and protein; high in fiber.
Old Process Oil Meal. American Linseed Co., New York City. Composed of flaxseed. Contains not more than 8 per cent crude fiber and not less than 5 per cent fat and 34 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Pure Old Process Ground Oil Cake. Archer Daniels Linseed Co., Buffalo, N. Y. Composed of product from manufacture of linseed oil. Contains not more than 10 per cent crude fiber and not less than 6 per cent fat and 33 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Pure Old Process Oil Meal. Spencer-Kellogg & Son Co., Buffalo, N. Y. Composed of ground linseed cake by-product in manufacture of linseed oil. Contains not more than 10 per cent crude fiber and not less than 5 per cent fat and 31 per cent protein.	Two official samples. In accord with guaranty.

WHEAT OFFALS—BRAN.

Angelus Wheat Bran GSNEMR. Thompson Milling Co., Lockport, N. Y. Composed of wheat bran. Contains not more than 15 per cent crude fiber and not less than 3 per cent fat and 11 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Bran. The Goshen Milling Co., Goshen, Indiana. Composed of wheat bran and wheat screenings not exceeding mill run. Contains not more than 11 per cent crude fiber and not less than 3.5 per cent fat and 14.5 per cent protein.	One official sample. In accord with guaranty.
Bran. Northland Milling Co., Ltd., Oak Lake, Man. Contains not more than 14.8 per cent crude fiber and not less than 3.4 per cent fat and 16.8 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Bran. Russell Miller Mlg. Co., Minneapolis, Minn. Made entirely from wheat. Contains not more than 11 per cent crude fiber and not less than 4 per cent fat and 13 per cent protein. Registered in 1919 and 1920.	Two official samples. In accord with guaranty.
Choice Wheat Bran with trace of screenings. Hecker-Jones Jewell Milling Co., Buffalo, N. Y. Made from wheat. Contains not more than 13 per cent crude fiber and not less than 3.25 per cent fat and 14 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Commander Bran. Commander Mill Co., Minneapolis, Minn. Product of wheat with ground screenings not exceeding mill run. Contains not more than 13.9 per cent crude fiber and not less than 3.5 per cent fat and 13 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Durum Wheat Bran GSNEMR. Pillsbury Flour Mills Co., Minneapolis, Minn. Composed of wheat bran and ground wheat screenings. Contains not more than 14 per cent crude fiber and not less than 4 per cent fat and 11 per cent protein.	One official sample. In accord with guaranty.
Duluth Imperial Bran. Duluth Superior Mlg. Co., Duluth, Minn. Composed of wheat bran with ground screenings not exceeding mill run. Contains not more than 12.25 per cent of crude fiber and not less than 4 per cent fat and 13.75 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Eaco Wheat Bran with GSNEMR. Everett Aughenbaugh & Co., Waseau, Minn. Contains not more than 12 per cent crude fiber and not less than 3 per cent fat and 14 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Extra Coarse Wheat Bran GSNEMR. The Blake Milling Co. Contains not more than 11 per cent crude fiber and not less than 4 per cent fat and 15.5 per cent protein. Registered in 1919. The guarantees as given are from the inspector's slip. No manufacturer's certificate received.	One official sample. In accord with guaranty.
Granite Wheat Bran GSNEMR. J. G. Davis. Rochester, N. Y. Contains not more than 12 per cent crude fiber and not less than 3 per cent fat and 14 per cent protein. Registered in 1919. The guarantees as given are from the inspector's slip. No manufacturer's certificate received.	One official sample. In accord with guaranty.
Gwinn's Wheat Bran. The Gwinn Milling Co., Columbus, Ohio. Composed of bran with screenings not exceeding mill run. Contains not more than 13.5 per cent crude fiber and not less than 4 per cent fat and 13 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Heywood Pure Bran. Heywood Milling Co., Jackson, Mich. Offals from milling of wheat flour containing no ground screenings or receivers' separator's dust. Contains not more than 12 per cent crude fiber and not less than 3.5 per cent fat and 11 per cent protein.	One official sample. In accord with guaranty.
Jersey Wheat Bran GSNEMR. The Century Milling Co., Minneapolis, Minn. Contains not more than 13 per cent crude fiber and not less than 4 per cent fat and 13 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Komo Pure Wheat Bran. St. Paul Milling Co., St. Paul, Minn. Pure wheat product. Contains not more than 12 per cent crude fiber and not less than 4 per cent fat and 14 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Le Grande Bran. The Loudonville Mill & Grain Co., Loudonville, Ohio. Wheat bran. Contains not more than 7 per cent crude fiber and not less than 4 per cent fat and 13 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Lucky Hard Wheat Bran with GSNEMR. Federal Milling Co., Lockport, N. Y. Contains not more than 14 per cent crude fiber and not less than 2.5 per cent fat and 13 per cent protein. Registered in 1919 and 1920.	Two official samples. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Mennels Fancy Bran Winter Wheat Feed. The Mennel Milling Company. Contains not more than 9.5 per cent crude fiber and not less than 4 per cent fat and 15 per cent protein. Registered in 1919. The guarantees as given are from the inspector's slip. No manufacturer's certificate received.	One official sample. In accord with guaranty.
National Feed Wheat Bran. National Milling Co., Minneapolis, Minn. Composed of wheat bran and middlings with ground screenings not exceeding mill run. Contains not more than 10 per cent crude fiber and not less than 3.75 per cent fat and 15 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Over Coat Pure Wheat Bran. The Mansfield Milling Co., Mansfield, Ohio. Pure wheat bran. Contains not more than 10 per cent crude fiber and not less than 4 per cent fat and 14 per cent protein.	One official sample. In accord with guaranty.
Pillsbury's Wheat Bran and GSNEMR. Pillsbury Flour Mills Co., Minneapolis, Minn. Contains not more than 13 per cent crude fiber and not less than 4 per cent fat and 13 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Red Turkey Pure Wheat Bran. The Southwestern Milling Co., Kansas City, Mo. Pure wheat bran. Contains not more than 11.8 per cent crude fiber and not less than 4 per cent fat and 14.5 per cent protein.	One official sample. In accord with guaranty.
Rob Roy Feed Winter Wheat Bran. Wm. A. Coombs Milling Co., Coldwater, Mich. Wheat bran with ground wheat screenings not exceeding mill run. Contains not more than 10 per cent crude fiber and not less than 3 per cent fat and 14 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Robin Hood Bran. Robin Hood Mills Ltd., Calgary, Alta., Canada. Composed of wheat bran with ground screenings not exceeding mill run. Contains not more than 12 per cent crude fiber and not less than 3 per cent fat and 14 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Seal of Minnesota Wheat Bran GSNEMR. New Prague Flouring Mill Co., New Prague, Minn. Contains not more than 12.5 per cent crude fiber and not less than 3 per cent fat and 13.3 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Star & Crescent Bran with GSNEMR. Star & Crescent Mlg. Co., Chicago, Ill. Contains not more than 10 per cent crude fiber and not less than 4 per cent fat and 15 per cent protein. Registered in 1919.	One official sample. In accord with guaranty in protein and fat; high in fiber.
Trojan Bran. The Allen & Wheeler Co., Troy, Ohio. Composed of pure offal from wheat screenings not exceeding mill run. Contains not more than 8.5 per cent crude fiber and not less than 4 per cent fat and 14.5 per cent protein.	One official sample. In accord with guaranty.
Victor Spring Wheat Bran GSNEMR. Victor Milling Co., Victor, N. Y. Composed of spring wheat and screenings. Contains not more than 15 per cent crude fiber and not less than 4 per cent fat and 14.6 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Voights Crescent Bran. Voight Milling Co., Grand Rapids, Mich. Composed of bran containing mill run of screenings. Contains not more than 11 per cent crude fiber and not less than 4 per cent fat and 14 per cent protein.	One official sample. In accord with guaranty.
Wheat Bran. Chas. M. Cox Co., Boston, Mass. Contains not more than 12 per cent crude fiber and not less than 4.5 per cent fat and 15.5 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Wheat Bran with MRS Not Exceeding 8%. The Larabee Flour Mills Corp., St. Joseph, Mo. Contains not more than 10 per cent crude fiber and not less than 3.25 per cent fat and 15 per cent protein. Registered in 1919. The guarantees as given are from the inspector's slip. This feed was not registered at time of sale.	Two official samples. In accord with guaranty.
Wheat Shorts, from Wheat Products and Ground Screenings. Peerless Milling & Feed Co., Cairo, Ill. Contains not more than 9 per cent crude fiber and not less than 4 per cent fat and 16 per cent protein. Registered in 1919. The guarantees as given are from the inspector's slip. This feed was not registered at time of sale.	One official sample. In accord with guaranty.
Wheat Bran GSNEMR. Stokes Milling Co. Contains not more than 13 per cent crude fiber and not less than 3.8 per cent fat and 14.5 per cent protein. The guarantees as given are from the inspector's slip. This feed was not registered at time of sale.	One official sample. In accord with guaranty.
Wheat Bran with GSNEMR. Washburn Crosby Co., Minneapolis, Minn. Contains not more than 13 per cent crude fiber and not less than 4 per cent fat and 13 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

WHEAT OFFALS—MIDDLINGS.

Acme Feed Wheat Bran, Wheat Middlings and GSNEMR. Acme Evans Co., Indianapolis, Ind. Composed of wheat bran, wheat middlings and not exceeding mill run of ground cleaned wheat screenings. Contains not more than 9 per cent crude fiber and not less than 4 per cent fat and 16 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Angelus Wheat Middlings GSNEMR. Thompson Milling Co., Lockport, N. Y. Composed of middlings, red dog, ground screenings not exceeding mill run. Contains not more than 15 per cent crude fiber and not less than 3 per cent fat and 11 per cent protein. Registered in 1919.	Three official samples. In accord with guaranty.
Bixota Wheat Middlings. Red Wing Milling Co., Red Wing, Minn. Composed of wheat middlings. Contains not more than 11.2 per cent crude fiber and not less than 5.1 per cent fat and 15.7 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Crescent Middlings. Voight Milling Co., Grand Rapids, Mich. Composed of middlings containing mill run of screenings. Contains not more than 10 per cent crude fiber and not less than 3 per cent fat and 14.5 per cent protein.	One official sample. In accord with guaranty.
C. V. Pure Wheat Middlings. Cannon Valley Milling Co. Contains not more than 9.8 per cent crude fiber and not less than 4 per cent fat and 16 per cent protein. The guarantees as given are from the inspector's slip. This feed was not registered at time of sale.	One official sample. In accord with guaranty.
Dairy Maid Winter Wheat Middlings GSNEMR. Federal Milling Co., Lockport, N. Y. Composed of wheat middlings with ground screenings not exceeding mill run. Contains not more than 10 per cent crude fiber and not less than 3 per cent fat and 13 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Gwinn's Wheat Middlings with GSNEMR. The Gwinn Milling Co., Columbus, Ohio. Composed of wheat middlings with screenings not exceeding mill run. Contains not more than 10 per cent crude fiber and not less than 4 per cent fat and 15 per cent protein. Registered in 1919.	One official sample. In accord with guaranty in protein. Not examined for fiber and fat.
Highland Wheat Middlings. Highland Milling Co., Highland, Ill. Composed of wheat middlings with ground screenings not exceeding mill run. Contains not more than 6 per cent crude fiber and not less than 4 per cent fat and 15 per cent protein.	One official sample. In accord with guaranty.
Le Grande Middlings. The Loudonville Mill & Grain Co., Loudonville, Ohio. Composed of wheat middlings with ground screenings not exceeding mill run. Contains not more than 7 per cent crude fiber and not less than 4 per cent fat and 15 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Lucky Flour Middlings. Federal Milling Co., Lockport, N. Y. Composed of wheat flour middlings with ground screenings not exceeding mill run. Contains not more than 10 per cent crude fiber and not less than 3.5 per cent fat and 14 per cent protein. Registered in 1919.	Two official samples. In accord with guaranty.
Middlings made from Pure Wheat. F. W. Stock & Sons, Hillsdale, Mich. Composed of wheat middlings. Contains not more than 6 per cent crude fiber and not less than 5 per cent fat and 16 per cent protein (1919 registration). Contains not more than 7 per cent crude fiber and not less than 4 per cent fat and 16 per cent protein (1920 registration).	Two official samples. The sample registered in 1920 in accord with guaranty. The sample registered in 1919 in accord with guaranty in protein and fat; high in fiber.
Money Maker Wheat Middlings GSNEMR. The Mansfield Milling Co., Mansfield, Ohio. Composed of pure wheat middlings ground screenings not exceeding mill run. Contains not more than 8 per cent crude fiber and not less than 4 per cent fat and 15 per cent protein.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Osakis Middlings. Osakis Milling Co., Osakis, Minn. Composed of wheat by-products no screenings mixed in. Contains not more than 11 per cent crude fiber and not less than 4 per cent fat and 15 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Pennant Middlings GSNEMR. David Stott Flour Mills, Detroit, Mich. Composed of brown wheat middlings with ground wheat screenings not exceeding mill run. Contains not more than 8 per cent crude fiber and not less than 5 per cent fat and 15.5 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Pillsbury's Wheat B. Middlings with GSNEMR. Pillsbury Flour Mills Co., Minneapolis, Minn. Composed of wheat shorts or standard middlings and ground wheat screenings. Contains not more than 11 per cent crude fiber and not less than 4 per cent fat and 14 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Poland Wheat Standard Middlings GSNEMR. The Century Milling Co., Minneapolis, Minn. Composed of wheat standard middlings with ground screenings not exceeding mill run. Contains not more than 11 per cent crude fiber and not less than 4 per cent fat and 14 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Purity Winter Wheat Middlings. The Capital Milling Co., Columbus, Ohio. Composed of ground screenings not exceeding mill run. Contains not more than 8.4 per cent crude fiber and not less than 4.5 per cent fat and 13.6 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Seal of Minnesota Wheat Standard Middlings. New Prague Flouring Mill Co., New Prague, Minn. Composed of wheat standard middlings with ground screenings not exceeding mill run. Contains not more than 7.75 per cent crude fiber and not less than 4.5 per cent fat and 15 per cent protein.	One official sample. In accord with guaranty.
Standard Middlings with Mill Run Screenings. Hecker-Jones-Jewell Milling Co., Buffalo, N. Y. Composed of wheat. Contains not more than 10 per cent crude fiber and not less than 5 per cent fat and 16 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Stott's Fine White Middlings. David Stott Flour Mills, Detroit, Mich. Composed of fine white wheat middlings. Contains not more than 6 per cent crude fiber and not less than 4.3 per cent fat and 14.8 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Snowball Flour Middlings. Shane Bros. & Wilson Co., Minneapolis, Minn. Composed of wheat flour middlings with ground wheat screenings not exceeding mill run. Contains not more than 8 per cent crude fiber and not less than 5.5 per cent fat and 16.5 per cent protein.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Superior Wheat Feed and Flour. F. W. Stock & Sons, Hillsdale, Mich. Composed of wheat feed and flour with mill run of screenings. Contains not more than 7 per cent crude fiber and not less than 4.5 per cent fat and 16 per cent protein. Registered in 1919.	One official sample. Practically in accord with guaranty.
Trojan Middlings. The Allen & Wheeler Co., Troy, Ohio. Contains not more than 6 per cent crude fiber and not less than 4 per cent fat and 15 per cent protein.	One official sample. In accord with guaranty in protein and fat; high in fiber.
True Value Pure Wheat Middlings. Stratton-Ladish Mlg. Co., Milwaukee, Wisconsin. Composed of wheat (no screenings). Contains not more than 9 per cent crude fiber and not less than 4 per cent fat and 15 per cent protein.	One official sample. In accord with guaranty.
Wheat Middlings GSNEMR. Ansted & Burk Co., Springfield, Ohio. Composed of wheat middlings with ground screenings not exceeding mill run. Contains not more than 5.5 per cent crude fiber and not less than 5 per cent fat and 16 per cent protein. Registered in 1919.	One official sample. In accord with guaranty in protein; slightly low in fat; high in fiber.
Wheat Middlings GSNEMR. Eagle Roller Mills Co., New Ulm, Minn. Composed of wheat middlings with ground screenings not exceeding mill run. Contains not more than 11 per cent crude fiber and not less than 4 per cent fat and 14 per cent protein.	One official sample. In accord with guaranty.
Wheat Middlings GSNEMR. Mosely & Motley Milling Co., Rochester, N. Y. Composed of wheat middlings with ground screenings not exceeding mill run. Contains not more than 10 per cent crude fiber and not less than 4.5 per cent fat and 15 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Wheat Middlings GSNEMR. Chas. M. Cox Co., Boston, Mass. Composed of wheat middlings from ground screenings not exceeding mill run. Contains not more than 11 per cent crude fiber and not less than 4 per cent fat and 13 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Wheat Standard Middlings. Shane Bros. & Wilson Co., Minneapolis, Minn. Composed of wheat middlings with ground screenings not exceeding mill run. Contains not more than 10.3 per cent crude fiber and not less than 5.3 per cent fat and 15.5 per cent protein.	One official sample. In accord with guaranty.
Wheat Standard Middlings GSNEMR. Washburn Crosby Co., Minneapolis, Minn. Composed of ground screenings not exceeding mill run. Contains not more than 11 per cent crude fiber and not less than 4 per cent fat and 14 per cent protein. Registered in 1919 and 1920.	Three official samples. In accord with guaranty.

WHEAT OFFALS—MIXED FEED.

Angelus Wheat Mixed Feed. Thompson Milling Co., Lockport, N. Y. Composed of wheat bran and wheat middlings run together with mill run of screenings. Contains not more than 15 per cent crude fiber and not less than 3 per cent fat and 11 per cent protein. Registered in 1919.	Two official samples. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Boston Mixed Feed. Duluth Superior Milling Co., Duluth, Minn. Composed of bran, middlings, red dog flour with ground screenings not exceeding mill run. Contains not more than 9.75 per cent crude fiber and not less than 4.5 per cent fat and 16 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Buckeye Feed Wheat Mixed Feed. Quaker Oats Co., Chicago, Ill. Composed of wheat mixed feed with ground screenings not exceeding mill run and rye middlings. Contains not more than 8.5 per cent crude fiber and not less than 4.5 per cent fat and 15.5 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Champion Mixed Feed GSNEMR. Portland Milling Co., Portland, Mich. Composed of mixed feed with ground screenings not exceeding mill run and wheat offal. Contains not more than 8.47 per cent crude fiber and not less than 3.58 per cent fat and 13.56 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Dairy Maid Winter Wheat Mixed Feed. Federal Milling Co., Lockport, N. Y. Composed of winter wheat mixed feed with ground screenings not exceeding mill run. Contains not more than 12 per cent crude fiber and not less than 2.75 per cent fat and 13 per cent protein.	One official sample. In accord with guaranty.
Delaware Mixed Wheat Feed. Morris Bros., Oneonta, N. Y. Composed of wheat bran, wheat middlings and wheat screenings. Contains not more than 10 per cent crude fiber and not less than 3.75 per cent fat and 15 per cent protein.	One official sample. In accord with guaranty.
E. A. Co., Mixed Feed GSNEMR. Everett Aughenbaugh & Co., Waseau, Minn. Composed of wheat bran middlings and ground screenings not exceeding mill run. Contains not more than 12 per cent crude fiber and not less than 3 per cent fat and 15 per cent protein.	One official sample. In accord with guaranty.
Golden Bull Mixed Feed. Lawrenceburg Roller Mills Co., Lawrenceburg, Indiana. Composed of pure wheat bran and middlings mixed. Contains ground screenings not exceeding mill run. Contains not more than 10.2 per cent crude fiber and not less than 2.5 per cent fat and 16 per cent protein.	One official sample. In accord with guaranty.
Highland Mixed Feed Wheat Bran & Middlings run together. Highland Milling Co., Highland, Ill. Contains not more than 9 per cent crude fiber and not less than 4 per cent fat and 15 per cent protein. Registered in 1919 and 1920.	Two official samples. In accord with guaranty.
Jenks Mixed Feed with GSNEMR. Huron Milling Co., Harbor Beach, Mich. Contains not more than 11.5 per cent crude fiber and not less than 3.5 per cent fat and 14 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Kent Mixed Feed. The Williams Bros. Co., Kent, Ohio. Composed of pure bran and middlings mixed. No ground screenings. Contains not more than 11 per cent crude fiber and not less than 3 per cent fat and 14 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

Brand, Maker and Guaranties.	Results of Examination.
Lucky Spring Wheat Mixed Feed GSNEMR. Federal Milling Co., Lockport, N. Y. Contains not more than 11 per cent crude fiber and not less than 3 per cent fat and 14 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Lucky Hard Wheat Mixed Feed GSNEMR. Federal Milling Co., Lockport, N. Y. Contains not more than 12 per cent crude fiber and not less than 3 per cent fat and 14 per cent protein.	One official sample. In accord with guaranty.
Mennels Winter Mixed Feed. Mennel Milling Co., Toledo, Ohio. Composed of winter wheat bran and winter wheat middlings with GSNEMR. Contains not more than 8 per cent crude fiber and not less than 4 per cent fat and 15 per cent protein.	One official sample. In accord with guaranty.
Mixed Feed. The Ansted & Burk Co., Springfield, Ohio. Composed of wheat bran and middlings mixed with GSNEMR. Contains not more than 11 per cent crude fiber and not less than 3.5 per cent fat and 14.5 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Mixed Feed with GSNEMR. Christian Breisch & Co., Lansing, Mich. Composed of wheat bran and wheat middlings, mixed. Contains not more than 8.47 per cent crude fiber and not less than 2.58 per cent fat and 13.56 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Mixed Feed GSNEMR. The Loudonville Mill & Grain Co., Loudonville, Ohio. Composed of mill run of bran and middlings. Contains not more than 7 per cent crude fiber and not less than 4 per cent fat and 15 per cent protein.	One official sample. In accord with guaranty.
Mixed Feed GSNEMR. Webster Mill Co. Contains not more than 10.4 per cent crude fiber and not less than 4.8 per cent fat and 15.3 per cent protein. Registered in 1919. The guarantees as given from the Inspector's slip. This feed was not registered at time of sale.	One official sample. In accord with guaranty.
Monarch Fancy Feed with Mill run screenings. F. W. Stock & Sons, Hillsdale, Mich. Composed of wheat bran and middlings with mill run of screenings. Contains not more than 10 per cent crude fiber and not less than 4 per cent fat and 16 per cent protein. Registered in 1919.	Two official samples. Slightly low in protein. The sample examined in accord in fiber and fat.
N. M. Co.'s Mixed Feed. Noblesville Milling Co., Noblesville, Indiana. Composed of wheat bran, middlings and ground wheat screenings not to exceed mill run. Contains not more than 8 per cent crude fiber and not less than 4 per cent fat and 16 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Peerless Mixed Feed. Fuller Holway Co., Augusta, Me. Composed of wheat, bran, middlings, low grade flour with GSNEMR. Contains not more than 7.9 per cent crude fiber and not less than 4 per cent fat and 14 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Peninsular Flour Mill, Wheat Mixed Feed GSNEMR. Deroo & Co., Flint, Mich. Composed of wheat bran and middlings with GSNEMR. Contains not more than 10 per cent crude fiber and not less than 4 per cent fat and 14 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Producer Wheat Mixed Feed GSNEMR. The Mansfield Milling Co., Mansfield, Ohio. Contains not more than 9 per cent crude fiber and not less than 4 per cent fat and 14 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Snowflake Mixed Feed. Lawrenceburg Roller Mills Co., Lawrenceburg, Indiana. Composed of pure soft wheat bran and middlings with GSNEMR. Contains not more than 8.5 per cent crude fiber and not less than 3 per cent fat and 14 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Soft Wheat Mixed Feed Mill Run Bran. Chas. M. Cox Co., Boston, Mass. Composed of shipsstuff shorts and bran from soft winter wheat. Contains not more than 10 per cent crude fiber and not less than 4 per cent fat and 15 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
S & P Wheat Mixed Feed and Screenings. The Rea-Patterson Milling Co. Contains not more than 8.8 per cent crude fiber and not less than 3.5 per cent fat and 16 per cent protein. Registered in 1919. The guarantees as given from the inspector's slip. This feed was not registered at time of sale.	One official sample. In accord with guaranty.
Stott's Heavy Pure mixed Wheat Feed. David Stott Flour Mills, Detroit, Mich. Composed of wheat bran, wheat middlings and wheat flour. Contains not more than 8 per cent crude fiber and not less than 4.5 per cent fat and 15 per cent protein. Registered in 1919 and 1920.	Two official samples. In accord with guaranty.
Trojan Mixed Feed. The Allen & Wheeler Co., Troy, Ohio. Contains not more than 9 per cent crude fiber and not less than 4 per cent fat and 14.5 per cent protein.	One official sample. In accord with guaranty.
Try-Me Mixed Feed GSNEMR. Sparks Milling Co., Alton, Ill. Composed of pure wheat bran, middlings and shorts with fine ground wheat screenings not exceeding mill run or two per cent. Contains not more than 9 per cent crude fiber and not less than 3.5 per cent fat and 16 per cent protein. Registered in 1919 and 1920.	Two official samples. In accord with guaranty.
Valiers Mixed Feed. Valier & Skies Milling Co., St. Louis, Mo. Composed of a mixture of wheat bran and wheat middlings with ground wheat screenings. Contains not more than 9 per cent crude fiber and not less than 4 per cent fat and 15 per cent protein.	One official sample. In accord with guaranty.
Wheat Mixed Feed, Gwinn's Dairy Feed. Gwinn Milling Co., Columbus, Ohio. Composed of bran and middlings with screenings not exceeding mill run. Contains not more than 11 per cent crude fiber and not less than 4 per cent fat and 14 per cent protein. Registered in 1919 and 1920.	Two official samples. In accord with guaranty.

FEEDING STUFFS—Continued.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
WHEAT OFFALS—RED DOG FLOUR, ETC.	
Adrian Red Dog. Washburn Crosby Co., Minneapolis, Minn. Composed of wheat. Contains not more than 4 per cent crude fiber and not less than 4 per cent fat and 16 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Arlington Second Clear. Washburn Crosby Co., Minneapolis, Minn. Composed of wheat. Contains not more than 4 per cent crude fiber and not less than 4 per cent fat and 14 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Red Dog. Hecker-Jones-Jewell Mlg. Co., Buffalo, N. Y. Made from wheat. Contains not more than 6 per cent crude fiber and not less than 5 per cent fat and 16.25 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Red Dog Wheat Flour. Shane Bros. & Wilson Co., Minneapolis, Minn. Low grade wheat flour. Contains not more than 4 per cent crude fiber and not less than 4 per cent fat and 16 per cent protein.	One official sample. In accord with guaranty.
Improved Grafton Wheat Feed. Grafton Milling Co., Grafton, N. Dak. Made from wheat products. Contains not more than 8.4 per cent crude fiber and not less than 2.7 per cent fat and 14 per cent protein. Registered in 1919.	One official sample. In accord with guaranty in protein and fat; slightly high in fiber.
Monarch Wheat Feed. F. H. Brastow & Son So. Brewer, Me. Composed of pure wheat feed. Contains not more than 8 per cent crude fiber and not less than 4 per cent fat and 14 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
Occident Wheat Feed. Russell Miller Milling Co., Minneapolis, Minn. Composed of mill run of wheat bran and middlings—made entirely from wheat. Contains not more than 10 per cent crude fiber and not less than 4.[illegible] per cent fat and 15 per cent protein. Registered in 1919.	Two official samples. In accord with guaranty.
Pure Mill Feed. Heywood Milling Co., Jackson, Mich. Composed of offal from wheat flour manufacture. Contains not more than 10 per cent crude fiber and not less than 3.7[illegible] per cent fat and 14 per cent protein. Registered in 1919.	Two official samples. In accord with guaranty.
Pure Wheat Red Dog Flour. The Century Milling Co. Contains not more than 4 per cent crude fiber and not less than 4 per cent fat and 16 per cent protein. The guarantees are as given from the inspector's slip. This feed was not registered at time of sale.	One official sample. In accord with guaranty.
Stag Flour. David Stott Flour Mills. Contains not more than 1.5 per cent crude fiber and not less than 2 per cent fat and 12.8 per cent protein. The guarantees as given are from the inspector's slip. This feed was not registered at time of sale.	One official sample. In accord with guaranty.

FEEDING STUFFS—Concluded.

BRAND, MAKER AND GUARANTIES.	RESULTS OF EXAMINATION.
Superior Wheat Feed and Flour with Mill Run Screenings. Composed of wheat feed and flour with mill run screenings. F. W. Stock & Sons, Hillsdale, Mich. Contains not more than 7 per cent crude fiber and not less than 4.5 per cent fat and 16 per cent protein. Registered in 1919.	Three official samples. One sample in accord with guaranty. One sample slightly low in protein guaranty; in accord in fiber and fat. One sample in accord with guaranty in protein and fat; slightly high in fiber.
Triangle Pure Wheat Red Dog. The Mansfield Mlg. Co., Mansfield, Ohio. Consists of a mixture of low grade flour, fine particles of bran and the fiberous offal from the "tail of the mill." Contains not more than 4 per cent crude fiber and not less than 4 per cent fat and 16 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.
True Value Red Dog. Stratton-Ladish Milling Co., Milwaukee, Wis. Composed of low grade flour. Contains not more than 4 per cent crude fiber and not less than 3.5 per cent fat and 14 per cent protein.	One official sample. In accord with guaranty.
Wirthmore Wheat Feed GSNEMR. Chas. M. Cox Co., Boston, Mass. Composed of wheat bran, red dog flour and less than mill run of screenings. Contains not more than 8 per cent crude fiber and not less than 4.5 per cent fat and 15 per cent protein. Registered in 1919.	One official sample. In accord with guaranty.

REFERENCE LIST OF FEEDING STUFFS REPORTED.

PAGE

October, 1920

MAINE
AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE.
CHAS. D. WOODS, Director

ANALYSTS.

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Official Inspections

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COMMERCIAL FERTILIZERS, 1920

CHAS. D. WOODS.

The Commissioner of Agriculture is the executive of the law regulating the sale of fertilizers in Maine. It is the duty of the Director of the Maine Agricultural Experiment Station to make the analyses of the samples collected by the Commissioner, and to publish the results of the analyses together with such additional information as may seem advisable.

NOTE. All correspondence relative to the inspection laws should be addressed to the Bureau of Inspections, Department of Agriculture, Augusta, Maine.

THE FERTILIZER LAW.

The fertilizer law was amended by the 1919 Legislature. The chief points as effective since July 1919 follow.

A commercial fertilizer is any material used for fertilizing purposes, the price of which exceeds ten dollars a ton. Each package or lot shall carry a plainly printed statement giving: the number of net pounds in the package; the name brand or trade mark; the name and principal address of maker; and a "chemical analysis stating the minimum percentage of nitrogen, available as plant food, present as nitrates, ammonia salts or organic nitrogen, of potash soluble in water, of phosphoric acid in available form, soluble and reverted, and of total phosphoric acid." All fertilizers must be registered with the Commissioner of Agriculture before being offered for sale.

A fertilizer is misbranded if: it fails to bear all of the statements named above; if these statements are not in accord with the certificate filed with the Commissioner of Agriculture; and if the registration fee has not been paid.

A fertilizer is adulterated "First, if its weight, composition, quality, strength or purity do not conform in each particular to the claims made upon the affixed guaranty. Second, if it contains any material deleterious to growing plants. Third, if it is found to contain any pulverized leather, hair, ground hoofs, horns, wool waste, peat, garbage tankage, cyanamide, or any nitrogenous ingredients derived from any inert material whatsoever, unless the same has been so treated as to be available as plant food as determined by the methods adopted by the association of official agricultural chemists, without an explicit printed statement of the fact, conspicuously affixed to the package of such fertilizer and accompanying and going with every lot or package of the same, in which fertilizer the above named materials aid in making up the required or guaranteed analysis."

The Commissioner of Agriculture is the executive of the law and the full text of the law will be sent on application to him at the State House, Augusta.

DESCRIPTION OF TABLES.

Even if you think you know what a fertilizer table means and that you know how to use it, it will not take much of your time to read the following. And it may be worth your while.

The reports of each brand appear upon two pages. The left hand page carries the number of the fertilizer, the name of the maker, his place of business, the name of the brand and the town where the sample was taken. The right hand page repeats the number of the sample and gives the detailed numerical results of the chemical examination. In folding the book the printer endeavors to make the lines run true across both pages. In case they are not strictly in line the repetition of the number of the sample makes it possible to go from the right to the left page without mistake.

THE NUMERICAL RESULTS OF THE ANALYSIS.

The followng shows the form of the table in use. For purposes of explanation and illustration results of four samples examined in 1918 are given. With the exception of the substitution of letters for the Station number they are as printed in the Official Fertilizer Inspection for 1918.

Analysis of Fertilizer Samples.

Station number	Water	Nitrogen					Phosphoric Acid				Potash	
					Total		Available		Total			
		As nitrate	As ammonia	Active	Found	Guaranteed	Found	Guaranteed	Found	Guaranteed	Found	Guaranteed
A	9.24	1.76	1.38	3.78	4.10	4.11	9.98	10.00	10.72	11.00	3.89	4.00
B-1	6.41	0.57	1.50	2.76	3.63	3.29	10.45	10.00	12.10	11.00	------	0.00
B-2	11.03	1.32	0.76	2.72	2.85	3.29	10.05	10.00	11.51	11.00	------	0.00
C	8.71	1.44	0.56	2.16	2.40	2.06	8.01	8.00	8.98	9.00	1.18	1.00

Water. The amount of water the goods carries has a marked effect upon the amount of the other constituents. Usually when the goods leave the factory they carry about 9 per

cent of water. If they are exposed to a moist air they are likely to take up water. If kept in a very dry place they will lose water. For the most part there is a greater tendency to absorb than to lose water. In the first instance the goods will increase in weight and in the second lose in weight. In the specimen table above the two samples B-1 and B-2 are the same brand from the same maker. Probably when they left the factory they both carried about 9 per cent of water. One has probably lost and the other gained about 2 per cent of water. A sample carrying less than 9 per cent of water will likely overrun its guaranteed analysis and a sample containing much more than 9 per cent of water is likely to fall short in one or more constituents. It is unfortunate that the difficulty of transporting suitable accurate scales from one place to another prevents the inspector actually weighing the packages from which his samples are drawn. No one thing would add more of value to fertilizer inspection than the actual weighing of packages which are sampled.

If the weight of the goods at time of sampling as compared with the claimed weight was known a simple calculation would show the actual content of the fertilizer when it left the factory. When the sample is taken it is at once put into a tightly sealed jar and kept sealed until the analysis is made. So the column headed water indicates the amount carried at the time the inspector drew the sample. It will be noted that samples A and C carry about 9 per cent of water as do the majority of samples examined. In considering the actual reported analysis due regard should be given to the amount of water the goods carry.

Nitrogen. The nitrogen may be present as mineral or organic or both mineral and organic. The mineral nitrogen will be present as a nitrate (usually nitrate of soda with more or less nitrate of potash) or as an ammonia salt, usually the sulphte of ammonia.

That one is not sure of getting the same amounts of different forms of nitrogen in different lots of the same brand is illustrated by B-1 and B-2 above, which are two samples from different lots of the same kind of goods. While they agree closely in the total mineral nitrogen, 2.07 per cent in B-1 and 2.08 per cent in B-2, B-1 carries only .57 per cent as nitrate while B-2 has 1.32 per cent. And B-1 has 1.50 per cent nitrogen as ammonia and B-2 only .76 per cent.

The organic nitrogen may be natural by-products such as animal and vegetable wastes or artificial organic forms. Cyanamide nitrogen is about the only artificial organic form occurring in fertilizers and that is used very sparingly by manufacturers. The nitrate nitrogen, ammonia nitrogen, cyanamide nitrogen, and part of the other organic nitrogen is water soluble. The organic nitrogen (other than cyanamide nitrogen) will differ greatly in its availability due to its source. By careful and painstaking pot experiments the availability of most common forms of waste organic nitrogen have been ascertained and a laboratory method has been worked out that agrees reasonably well with the vegetative trials. So that the Experiment Stations of the Northeastern part of the United States have agreed upon a chemical mehod which gives an index to the character of the waste organic nitrogen used in making fertilizers. Some manufacturers of fertilizers use a wet process treatment of these low grade waste organic nitrogen materials whereby they are rendered far more available to plants than before being treated. This treated material has been tested out in vegetative experiments and the laboratory method has also been found to give a reasonable measure of the availability of this nitrogen. The column headed Active gives the total of the water soluble nitrogen and the waste organic nitrogen that can be counted upon as available to plants the first season the goods are applied. The active nitrogen bears some such relation to the total nitrogen as available phosphoric acid bears to total phosphoric acid. Under the Maine law the nitrogen is supposed to be guaranteed as "available nitrogen" but as will be noted from the table in most cases this agrees much more closely with the total than with the active nitrogen that the goods carry.

That there is of necessity no close relation between the total and the active nitrogen is illustrated by B-1 and B-2 above. The total nitrogen found in B-1 is 3.63 per cent and in B-2 only 2.85 per cent. But the active nitrogen is practically the same in both (B-1 2.76 per cent and B-2 2.72 per cent).

From the data given in the table all of the forms of nitrogen that the goods may carry with the exception of cyanamide nitrogen can be obtained. If, for instance, it is desired to know the percentage of organic nitrogen carried by any sample it

can be ascertained by subtracting the mineral nitrogen from the total nitrogen. For instance in sample A above one finds the mineral nitrogen by adding the nitrate nitrogen (1.76 per cent) and the ammonia nitrogen (1.38 per cent) together. Subtracting this sum (3.14 per cent) from the total nitrogen as found (4.10 per cent) the difference shows the organic nitrogen in the sample to be .96 per cent.

And if one wishes to know the amount of inactive organic nitrogen a fertilizer contains it is readily found by subtracting the active from the total found. Thus in A this inactive organic nitrogen is (4.10 less 3.78) .32 per cent.

It has also been found in vegetation experiments that in good grade organic nitrogen more than one-half of the nitrogen is available (active) for plant use. In A above the organic nitrogen is .96, the inactive is .32 per cent or less than one-third the total. This shows the organic nitrogen in A to have been from good sources. In like manner B-1 with its high (3.63 per cent) total nitrogen has 1.56 per cent organic (3.63 per cent less the mineral nitrogen 2.07 per cent). But of this 1.56 per cent total organic .86 per cent (3.63 less 2.76) is inactive. That is much less than half of the organic nitrogen is in the active (available) form and the organic nitrogen used is of poor quality. But the story with B-2 is quite different though it is another sample from another lot of the same brand. In this case there is .77 per cent organic (2.85 total found less 2.08 mineral nitrogen) of which only .13 per cent (2.85 total less 2.72 active) is inactive. That is about five-sixths of the organic nitrogen is available showing the organic nitrogen to be of high quality. By the total nitrogen B-1 would look far superior to B-2 but the active nitrogen is about alike in both. B-1 seems so far as total nitrogen is concerned to be above the guaranty and B-2 below. In fact from the standpoint of the Maine law which calls for a guaranty of available nitrogen they are both below the 3.29 per cent guaranty.

The column headed Active Nitrogen gives the information at a glance as to the relation between the nitrogen guaranteed and that which plants will make use of in the first year. But it is important for the grower of crops to consider the mineral nitrogen and the character of the organic nitrogen as outlined in the preceding paragraphs. Fertilizer tables are not like a

multiplication table or a table of logarithms. For they contain information beyond that obtained at a glance. It is particularly worth while to know the kind, character and amounts of the nitrogen.

Phosphoric Acid. In fertilizers phosphoric acid is usually present in three forms, water soluble, weak organic acid soluble, and insoluble. The water soluble and weak organic acid soluble together make up the available phosphoric acid. Other than that the water soluble is a little better distributed in the soil there is no choice from the standpoint of plant growth between the water soluble and the weak organic acid soluble. For very soon after its introduction into the soil the water soluble is changed to organic acid soluble form.

The insoluble phosphoric acid is readily found by subtracting the available phosphoric acid found from the total found. Thus in sample A above the insoluble phosphoric acid is .74 (10.72 less 9.98) per cent. Such small amounts as 1 per cent of insoluble phosphoric acid in the amounts in which fertilizers are applied per acre have no appreciable agricultural value. Its declaration serves no very useful purpose. But as in the methods of analysis in order to know the available, the total phosphoric acid must be determined, and from the fact that in the days in which financial values of fertilizers were calculated credit was given for the insoluble phosphoric acid, it continues to appear in the fertilizer laws and consequently in the reports. It is really a column that contains little information of value to the user of commercial fertilizers.

Potash. This column of potash found gives the amount of water soluble potash the goods carry. Until Germany declared war on civilization practically all of the world's potash was derived from mines in the German Empire. It was mostly in the form of muriate or sulphate and was of reasonable purity. With the war shutting off all sources of imported potash the United States had to look within its own borders for potash for munition and for growing crops. This lead to the opening up of new, untried, and very unusual sources which because of the price that could be had were developed as under old conditions they could not. While some of these goods, particularly potash salts derived from Searles Lake and Chili saltpeter, carried many impurities, the processes of manufacture have been so far

improved that American made potash salts of reasonable purity are now available in quantity and quality for the manufacture of fertilizers.

HOW CAN THE USER OF FERTILIZERS BE PROTECTED BY THE LAW?

During the past 20 years there has been such a decided economic change that fertilizer manufacturing has been practically revolutionized. Less than a generation ago fertilizers were practically all made by the use of a few standard materials such as nitrate of soda, sulphate of ammonia, dried blood, dissolved bone black, and muriate or sulphate of potash. When a manufacturer put out a definite formula it practically always, year after year, carried the same constituents in practically the same proportions. Furthermore these goods were shipped into large storehouses in Maine and it was possible for the inspector to go to these storehouses and draw a sample from packages out of a lot of a 100 to 500 tons of each brand. Because of the rather comparatively uniformity of mauufacture and the samples taken from such large shipments the occasional random sample fairly represented the goods which were given to the consumer.

The shortage and scarcity and variety of material entering into mixed goods have brought it about that even the most reliable standard brands are liable to be made up in a single season on quite different formulas although they would give the same ultimate analyses. Furthermore these goods instead of being shipped in large quantities into warehouses are for the most part sent directly to the user, and hence the samples collected by the inspectors are rarely representative of more than a few tons. This diversity of manufacturing formulas for making up the goods of the same brand and analyses was clearly brought out in cooperation with the companies in looking up the borax situation in 1919. It has also been very evident in the different analyses showing the different sources of nitrogen in the different samples of the same brands as they have been examined in recent years.

This economic situation is a fact, and the consumer must adjust himself to these new conditions in order to have a some-

what similar protection from the fertilizer inspection that he had in earlier years when the brands ran far more uniform in their manufacturing formulas than is now possible.

Because of the physical impossibility of analyzing all of the samples that might be collected and sent to the Experiment Station or the Department of Agriculture, it is suggested that the moment the consumer receives his fertilizer for 1921 that he take a sample of the goods in accordance with directions which are briefly stated below.

CONCISE DIRECTIONS FOR SAMPLING FERTILIZERS.

The sample may be taken by means of a sampling tube that reaches the whole length of the package or as follows:

Provide a teacup, a large sheet of strong paper, and for each sample a clean and dry pint or quart glass fruit jar fitted with a rubber ring.

Open at least five full and unbroken packages, and thoroughly mix the contents of each for a foot in depth; take out three cupfulls from different parts of the mixed portion of each package, pour them over one another upon a paper and intermix thoroughly but quickly to avoid loss or gain of moisture; fill the jar from this mixture; seal with wax and attach to the jar some such a statement as follows:

This jar contains a sample of fertilizer taken by me in the presence of Mr...as witness.

I certify that the sample is from five unopened packages as received by me on (insert date) and that to the best of my knowledge and belief the sample fairly represents the stock from which it was taken; and said stock was properly housed and in good condition.

The following is an exact copy of the printing upon or attached to the package: (This should give: the name of the goods; the name of the maker; the kind of package, whether barrel or bag; the weight, and a copy of the guaranteed analyses showing the percentage of nitrogen, available phosphoric acid and potash.)

Signed..

Post Office address..

Descriptive List of Fertilizer Samples, 1920.

Station number.	Manufacturer, Place of Business and Brand	Sample taken at
	AMERICAN AGRICULTURAL CHEMICAL CO., NEW YORK CITY.	
5831	A. A. C. Co. High Grade Acid Phosphate	Eliot
5828	Ammoniated Fertilizer AAA	Eliot
5808	Ammoniated Fertilizer AAAA	Norway
5597	Aroostook Potato Manure	Searsport
5689	Aroostook Potato Manure	Houlton
5607	Bradley's Blood, Bone & Potash	Belfast
5625	Bradley's Blood, Bone & Potash	Portland
5586	Bradley's Corn Phosphate	Bangor
5636	Bradley's Corn Phosphate	Portland
5640	Bradley's Eclipse Phosphate	Portland
5587	Bradley's Northland Potato Grower	Bangor
5599	Bradley's Northland Potato Grower	Searsport
5650	Bradley's Potato Fertilizer	Portland
5632	Bradley's Potato Manure	Portland
5615	Bradley's Reliable 6% Potash Fertilizer	Belfast
5626	Bradley's Reliable 6% Potash Fertilizer	Portland
5584	Bradley's Root Crop Manure	Bangor
5583	Bradley's Special Corn Phosphate without Potash	Bangor
5624	Bradley's Special Corn Phosphate without Potash	Portland
5579	Bradley's Special Potato Fertilizer without Potash	Bangor
5622	Bradley's Special Potato Fertilizer without Potash	Portland
5591	Bradley's Special Potato Manure without Potash	Bangor
5623	Bradley's Special Potato Manure without Potash	Portland
5815	Bradley's Three Star * * * Special with Potash	Bowdoinham
5589	Bradley's XL Superphosphate of Lime	Bangor
5631	Bradley's XL Superphosphate of Lime	Portland
5588	Bradley's XL Superphosphate without Potash	Bangor
5621	Bradley's XL Superphosphate without Potash	Portland
5581	Cereal & Root Fertilizer	Bangor
5644	Cereal & Root Fertilizer	Portland
5801	Complete Potato Mixture	Richmond
5829	Crocker's Ammoniated Corn Phosphate	Eliot
5830	Crocker's New Rival Ammoniated Superphosphate	Eliot
5832	Crocker's Potato Hop & Tobacco Fertilizer 1920	Eliot
5593	Darling's Big Four Potato Grower	Searsport
5655	Darling's Big Six Potato Grower	Presque Isle
5595	Darling's Blood, Bone & Potash	Searsport

Analysis of Fertilizer Samples, 1920.

Station number.	Water	Nitrogen					Phosphoric Acid				Potash	
		As nitrate	As ammonia	Active	Total		Available		Total		Found	Guaranteed
					Found	Guaranteed	Found	Guaranteed	Found	Guaranteed		
5831	9.46	------	0.00	0.00	0.00	0.00	16.46	16.00	17.21	17.00	0.00	0.00
5828	7.47	0.32	0.90	2.19	2.53	2.47	9.71	10.00	11.99	11.00	------	------
5808	9.09	1.04	1.34	3.26	3.58	3.29	10.01	10.00	11.91	11.00	------	------
5597	8.85	1.44	1.28	3.67	4.21	4.11	8.42	8.00	9.57	9.00	7.00	7.00
5689	9.29	1.74	1.06	3.95	4.22	4.11	8.38	8.00	9.35	9.00	7.13	7.00
5607	7.84	1.82	1.20	3.72	4.24	4.11	8.46	8.00	9.28	9.00	7.07	7.00
5625	8.11	1.80	0.90	3.65	4.10	4.11	8.34	8.00	9.83	9.00	7.11	7.00
5586	7.34	0.50	1.00	1.48	1.86	1.65	8.07	8.00	8.95	9.00	2.23	2.00
5636	8.28	0.40	0.54	1.37	1.82	1.65	8.44	8.00	9.57	9.00	2.16	2.00
5640	8.78	0.26	0.52	1.40	1.46	0.82	8.11	8.00	8.98	9.00	2.19	2.00
5587	8.73	0.66	1.62	2.98	3.38	3.29	8.15	8.00	9.17	9.00	3.86	4.00
5599	8.51	1.30	0.72	3.00	3.49	3.29	8.34	8.00	9.44	9.00	4.00	4.00
5650	8.74	0.44	0.60	1.74	1.88	1.65	8.36	8.00	9.03	9.00	3.23	3.00
5632	8.63	0.92	0.80	2.32	2.70	2.47	9.30	8.00	9.72	9.00	4.02	4.00
5615	8.67	0.94	1.34	3.30	3.66	3.29	8.18	8.00	9.38	9.00	6.15	6.00
5626	8.10	1.58	0.90	3.12	3.42	3.29	8.44	8.00	9.64	9.00	6.28	6.00
5584	8.92	0.72	1.34	2.94	3.22	3.29	10.03	10.00	11.28	11.00	------	------
5583	4.42	0.06	0.68	1.56	1.83	1.65	9.74	10.00	12.28	11.00	----	
5624	5.00	0.20	0.46	1.66	2.12	1.65	9.81	10.00	12.01	11.00	------	------
5579	4.38	0.20	0.86	1.70	1.97	1.65	9.70	10.00	12.09	11.00	------	------
5622	6.49	0.08	0.34	1.57	1.86	1.65	9.62	10.00	11.85	11.00	------	------
5591	5.85	0.42	1.14	2.35	2.62	2.47	9.98	10.00	12.09	11.00	------	------
5623	6.29	0.12	0.38	1.57	1.90	2.47	9.66	10.00	11.77	11.00	------	------
5815	13.88	0.70	1.10	2.36	2.54	2.47	7.84	8.00	8.71	9.00	2.88	3.00
5589	7.61	0.32	1.16	2.43	2.76	2.47	8.74	9.00	10.64	10.00	2.04	2.00
5631	9.33	0.64	0.86	2.28	2.65	2.47	9.54	9.00	11.17	10.00	2.20	2.00
5588	5.91	0.40	1.16	2.17	2.61	2.47	10.05	10.00	12.08	11.00	------	------
5621	8.50	0.70	0.44	2.20	2.62	2.47	9.68	10.00	11.31	11.00	------	------
5581	7.08	0.38	1.26	2.45	2.73	2.47	9.89	10.00	11.90	11.00	------	------
5644	8.74	0.52	0.66	2.30	2.68	2.47	9.75	10.00	11.14	11.00	------	------
5801	8.02	0.88	1.00	2.53	2.76	2.47	8.04	8.00	9.19	9.00	4.14	4.00
5829	7.81	0.32	0.64	1.82	1.78	1.65	7.42	8.00	8.45	9.00	2.39	2.00
5830	6.94	0.16	0.30	0.65	0.80	0.82	8.00	8.00	9.44	9.00	2.47	2.00
5832	9.09	0.48	0.82	2.37	2.57	1.65	8.83	8.00	9.85	9.00	2.72	3.00
5593	8.72	1.26	0.80	2.72	3.29	3.29	8.53	8.00	9.70	9.00	4.04	4.00
5655	8.43	0.96	1.40	3.03	3.25	3.29	8.59	8.00	9.43	9.00	6.09	6.00
5595	8.49	1.58	1.20	3.76	4.27	4.11	8.29	8.00	9.41	9.00	7.04	7.00

Descriptive List of Fertilizer Samples, 1920.

Station number.	Manufacturer, Place of Business and Brand	Sample taken at
5629	Four-Eight-Six Fertilizer	Portland
5729	Four-Eight-Six Fertilizer	Caribou
5580	Grain & Seeding Fertilizer	Bangor
5627	Grain & Seeding Fertilizer	Portland
5800	Great Eastern General	Richmond
5604	Great Eastern Superior Potato Grower	Belfast
5806	Great Eastern Superior Potato Grower	Norway
5690	Great Eastern Victory Potato Special	Houlton
5720	Great Eastern Victory Potato Special	Belfast
5592	Liberty Brand High Grade Fertilizer	Searsport
5646	Liberty Brand High Grade Fertilizer	Portland
5590	Monarch Potato Manure	Bangor
5606	Monarch Potato Manure	Belfast
5611	Northern Maine Potato Special	Belfast
5807	Packer's Union Potato Manure	Norway
5809	Pulverized Sheep Manure	Lewiston
5825	Quinnipiac Corn Manure	Saco
5824	Quinnipiac Potato Manure	Saco
5843	Quinnipiac Potato Phosphate	Springvale
5628	Sixteen Per cent Plain Superphosphate	Portland
5582	Special Vegetable Fertilizer	Bangor
5585	Universal Phosphate	Bangor
5641	Universal Phosphate	Portland
5638	Williams & Clark Americus Ammoniated Bone Superphosphate	Portland
5637	Williams & Clark Americus Corn Phosphate	Portland
5651	Williams & Clark Americus Potato Manure	Portland
5645	Williams & Clark Potato Phosphate	Portland
5823	Williams & Clark Special Americus Potato Manure without Potash	Saco
	ARMOUR FERTILIZER WORKS, BALTIMORE MD.	
5669	Armour's Bone Blood & Potash	Presque Isle
5692	Armour's Bone Blood & Potash	Mars Hill
5792	Tuscarora's 4-8-4	Bucksport
5698	Tuscarora's 5-8-7	Ft. Fairfield
	AROOSTOOK FEDERATION OF FARMERS, CARIBOU, MAINE.	
5667	Fish Meal	Washburn
5733	Dry Tankage, Second Grade	Mapleton

Analysis of Fertilizer Samples, 1920.

Station number	Water	Nitrogen: As nitrate	Nitrogen: As ammonia	Nitrogen: Active	Nitrogen: Total: Found	Nitrogen: Total: Guaranteed	Phosphoric Acid: Available: Found	Phosphoric Acid: Available: Guaranteed	Phosphoric Acid: Total: Found	Phosphoric Acid: Total: Guaranteed	Potash: Found	Potash: Guaranteed
5629	7.31	1.60	1.02	3.23	3.64	3.29	8.67	8.00	9.76	9.00	6.43	6.00
5729	9.67	1.00	1.24	3.29	3.37	3.29	8.08	8.00	9.13	9.00	6.22	6.00
5580	4.56	------	0.78	1.67	1.85	1.65	9.69	10.00	12.33	11.00	------	------
5627	5.80	0.12	0.52	1.79	2.15	1.65	10.36	10.00	12.33	11.00	------	------
5800	7.49	0.32	0.28	1.05	1.16	0.82	8.27	8.00	9.06	9.00	4.02	4.00
5604	8.83	1.28	0.72	2.88	3.28	3.29	8.19	8.00	9.31	9.00	4.02	4.00
5806	8.96	1.16	1.18	3.21	3.59	3.29	8.05	8.00	9.49	9.00	4.02	4.00
5690	7.09	1.28	0.90	3.19	3.33	3.29	8.42	8.00	9.14	9.00	6.27	6.00
5720	8.50	1.30	0.82	3.37	3.71	3.29	8.77	8.00	9.27	9.00	6.27	6.00
5592	8.72	1.50	1.24	3.69	4.26	4.11	8.20	8.00	9.48	9.00	7.04	7.00
5646	9.20	1.04	1.10	3.59	3.97	4.11	8.26	8.00	9.38	9.00	6.75	7.00
5590	10.26	0.74	1.54	3.10	3.49	3.29	8.31	8.00	9.32	9.00	3.73	4.00
5606	8.37	1.20	1.06	3.08	3.50	3.29	8.34	8.00	9.44	9.00	4.08	4.00
5611	10.07	1.36	1.68	3.81	4.28	4.11	8.71	8.00	9.65	9.00	4.22	4.00
5807	10.38	0.60	0.80	2.24	2.58	1.65	11.11	10.00	12.16	11.00	5.87	4.00
5809	5.71	------	------	------	2.39	2.06	1.04	--------	1.74	1.35	2.63	1.00
5825	9.28	0.52	0.64	1.85	2.05	1.65	8.35	8.00	9.30	9.00	2.21	2.00
5824	8.97	0.56	1.10	2.34	2.54	2.47	8.02	8.00	9.01	9.00	4.83	4.00
5843	8.10	0.28	0.70	1.77	2.04	1.65	7.61	8.00	9.35	9.00	2.97	3.00
5628	9.59	------	------	------	------	------	16.62	16.00	17.42	17.00	------	------
5582	8.58	0.76	1.46	3.07	3.35	3.29	10.08	10.00	11.52	11.00	------	------
5585	6.17	0.32	0.14	0.80	0.90	0.82	7.30	8.00	7.69	9.00	1.93	2.00
5641	9.48	0.28	0.39	0.80	1.00	0.82	8.32	8.00	8.98	9.00	2.08	2.00
5638	9.31	0.88	0.77	2.19	2.55	2.47	9.76	9.00	11.15	10.00	2.59	2.00
5637	8.70	0.34	0.60	1.49	1.85	1.65	8.14	8.00	9.40	9.00	2.15	2.00
5651	8.65	0.60	0.64	1.88	2.05	1.65	8.60	8.00	9.32	9.00	3.18	3.00
5645	8.64	0.82	0.78	2.31	2.52	2.47	8.12	8.00	8.98	9.00	4.06	4.00
5823	8.61	0.32	0.74	1.81	2.01	1.65	9.39	10.00	11.58	11.00	------	------
5699	8.12	0.64	2.28	3.76	4.08	4.11	8.50	8.00	9.12	9.00	7.35	7.00
5692	9.30	0.90	1.84	3.88	4.15	4.11	8.47	8.00	9.02	9.00	7.34	7.00
5792	11.08	1.08	1.28	3.35	3.68	3.29	9.00	8.00	9.65	9.00	4.29	4.00
5698	8.95	1.30	1.56	4.10	4.39	4.11	8.41	8.00	8.87	9.00	7.19	7.00
5667	17.22	------	------	------	6.68	8.15	--------	------	5.76	--------	------	------
5733	4.78	------	------	------	4.36	6.00	--------	2.5	18.36	--------	------	------

Descriptive List of Fertilizer Samples, 1920.

Station number.	Manufacturer, Place of Business and Brand	Sample taken at
5665	Muriate of Potash	Washburn
5666	Nitrate of Soda	Washburn
5841	Tankage	Houlton
5734	Tankage, High Grade	Mapleton
5735	U. S. Potash, Muriate of Potash	Mapleton
	BOWKER FERTILIZER CO., BOSTON, MASS.	
5708	Bowker's All Round Fertilizer	Portland
5740	Bowker's All Round Fertilizer	Dexter
5707	Bowker's Corn, Grain & Grass Phosphate	Portland
5678	Bowker's Four-Ten Hill & Drill	Houlton
5715	Bowker's Hill & Drill Phosphate	Portland
5710	Bowker's Potato & Vegetable Phosphate	Portland
5741	Bowker's Potato & Vegetable Phosphate	Dexter
5711	Bowker's 16% Acid Phosphate	Portland
5717	Bowker's Square Brand Farm & Garden Phosphate	Portland
5712	Bowker's Sure Crop Phosphate	Portland
5716	Bowker's Three-Ten All Round	Portland
5713	Bowker's Two-Ten Farm & Garden	Portland
5613	Stockbridge "B" General Crop Manure	Belfast
5677	Stockbridge Early Crop Manure	Houlton
5596	Stockbridge Early Crop Manure	Searsport
5600	Stockbridge Market Garden Manure	Searsport
5675	Stockbridge Market Garden Manure	Houlton
	JOSEPH BRECK & SONS, CORP., BOSTON, MASS.	
5718	Ramshead Brand Pulverized Sheep Manure	Sanford
	CANADIAN FERTILIZER CO., LTD., CHATHAM, ONT., CANADA.	
5730	Best by Test 4-6-10 Fertilizer	Caribou
5737	Best by Test 4-6-10 Fertilizer	Newport
	CHICAGO FEED & FERTILIZER CO., CHICAGO ILL.	
5838	Magic Brand Pulverised Sheep Manure	Lewiston
	COE-MORTIMER CO., NEW YORK CITY.	
5695	E. Frank Coe's Celebrated Special Potato Fertilizer Revised	Belfast
5688	E. Frank Coe's Celebarted Special Potato Fertilizer Revised	Houlton
5749	E. Frank Coe's Columbian Corn & Potato Fertilizer	West Farmington
5765	E. Frank Coe's Columbian Corn & Potato Fertilizer	Harmony
5616	E. Frank Coe's Complete Manure with 6% Potash	Belfast
5691	E. Frank Coe's Complete Manure with 6% Potash	Mars Hill
5739	E. Frank Coe's Corn King	Dexter
5748	E. Frank Coe's Corn King	West Farmington

Analysis of Fertilizer Samples, 1920.

Station number	Water	Nitrogen					Phosphoric Acid				Potash	
		As nitrate	As ammonia	Active	Total		Available		Total			
					Found	Guaranteed	Found	Guaranteed	Found	Guaranteed	Found	Guaranteed
5665	0.64	------	------	------	------	------	------	------	------	------	49.68	48.00
5666	0.79	15.00	------	15.00	15.00	18.00	------	------	------	------	------	------
5841	7.04	------	------	------	6.71	6.00	------	------	12.14	------	------	------
5734	12.80	------	------	------	8.86	4.94	------	2.50	3.90	------	------	------
5735	4.78	------	------	------	------	------	------	------	------	------	57.36	48.00
5708	8.78	0.70	0.76	2.40	2.77	2.47	8.48	8.00	9.30	9.00	3.63	4.00
5740	7.88	0.54	0.68	2.26	2.42	2.47	7.71	8.00	9.56	9.00	3.80	4.00
5707	8.13	0.48	0.96	1.75	1.88	1.65	8.51	8.00	9.17	9.00	2.30	2.00
5678	10.28	1.22	1.04	3.20	3.42	3.29	9.63	10.00	10.83	11.00	------	------
5715	9.18	1.12	0.54	2.46	2.69	2.47	9.34	9.00	10.96	10.00	2.01	2.00
5710	8.64	0.66	0.68	1.93	2.14	1.65	7.87	8.00	8.71	9.00	3.68	3.00
5741	8.23	0.66	0.54	2.13	2.29	1.65	8.73	8.00	10.10	9.00	2.85	3.00
5711	7.30	------	------	------	------	------	16.89	16.00	18.25	17.00	------	------
5717	9.35	0.72	0.34	1.89	2.01	1.65	8.89	8.00	9.76	9.00	2.43	2.00
5712	7.28	0.13	0.30	0.97	1.08	0.82	8.29	8.00	10.00	9.00	1.94	2.00
5716	8.75	0.82	0.80	2.64	3.01	2.47	9.97	10.00	11.79	11.00	------	------
5713	9.09	0.32	0.96	1.91	2.10	1.65	10.03	10.00	11.46	11.00	------	------
5613	8.99	0.86	1.44	3.29	3.65	3.29	8.04	8.00	9.44	9.00	6.28	6.00
5677	8.79	1.44	1.32	3.75	4.16	4.11	8.41	8.00	9.57	9.00	7.01	7.00
5596	8.60	1.50	1.24	3.76	4.24	4.11	8.20	8.00	9.35	9.00	7.00	7.00
5600	8.78	1.34	0.82	2.88	3.29	3.29	8.42	8.00	9.54	9.00	4.14	4.00
5675	8.41	1.20	1.16	3.19	3.50	3.29	8.14	8.00	9.08	9.00	4.17	4.00
5718	9.84	------	------	------	2.28	2.25	------	------	1.37	1.00	2.30	3.00
5730	16.45	0.96	0.38	2.67	3.11	3.30	7.99	6.00	8.19	7.00	9.35	10.00
5737	15.59	1.18	0.40	3.10	3.44	3.30	7.66	6.00	7.99	7.00	9.71	10.00
5838	10.53	------	------	------	1.83	1.85	------	1.43	1.79	1.50	2.77	1.25
5605	8.21	1.16	1.06	3.04	3.48	3.29	8.21	8.00	9.28	9.00	4.09	4.00
5688	7.86	1.34	0.88	2.89	3.31	3.29	8.28	8.00	10.13	9.00	3.97	4.00
5749	6.73	0.78	0.14	1.91	2.06	1.65	8.30	8.00	9.24	9.00	3.23	3.00
5765	8.71	0.54	0.60	1.68	1.83	1.65	9.07	8.00	9.81	9.00	2.97	3.00
5616	8.27	0.80	1.38	3.30	3.60	3.29	8.16	8.00	9.51	9.00	6.23	6.00
5691	9.89	0.64	1.44	3.35	3.55	3.29	8.22	8.00	9.54	9.00	6.07	6.00
5739	9.05	------	0.90	2.22	2.53	2.47	9.39	9.00	10.46	10.00	2.24	2.00
5748	8.81	0.88	0.50	2.41	2.63	2.47	9.34	9.00	10.40	10.00	2.26	2.00

Descriptive List of Fertilizer Samples, 1920.

Station number.	Manufacturer, Place of Business and Brand	Sample taken at
5738	E. Frank Coe's Gold Brand Excelsior Guano Revised	Dexter
5751	E. Frank Coe's Gold Brand Excelsior Guano Revised	West Farmington
5833	E. Frank Coe's New Englander Special	Temple
5664	E. Frank Coe's Potato & Truck Manure	Caribou
5693	E. Frank Coe's Potato & Truck Manure	Presque Isle
5810	E. Frank Coe's Prolific Crop Producer	So. Paris
5750	E. Frank Coe's 16% Superphosphate	West Farmington
5766	E. Frank Coe's 16% Superphosphate	Harmony
5608	E. Frank Coe's Vegetable Grower	Belfast
	DOMINION FERTILIZER CO., ST. STEPHEN N. B.	
5663	Dominion 5-8-7	Caribou
5773	Dominion 5-8-7	Calais
5662	Dominion 4-8-4	Caribou
5772	Dominion 4-8-7	Calais
5774	Dominion 4-9-1	Calais
5771	Dominion 3-8-4	Calais
5775	Dominion Vegetable, Corn & Grain 2-9-1	Calais
	ESSEX FERTILIZER CO., BOSTON, MASS.	
5816	Essex Fish Fertilizer 3-8-3	Bowdoinham
5747	Essex 4-8-4	Livermore Falls
5659	Essex 4-8-6	Limestone
5814	Essex Grain, Grass & Potato Fertilizer 1-10	Bowdoinham
5700	Essex Market Garden 3-8-4 for Vegeetables & Grass	Winthrop
5745	Essex 1-10-1	Winthrop
5746	Essex 2-8-2	Livermore Falls
	HUBBARD FERTILIZER CO., BALTIMORE, MD.	
5656	Hubbard Fertilizer 4-8-4	Presque Isle
	INTERNATIONAL AGRICULTURAL CHEMICAL CORPORATION, BUFFALO FERTILIZER WORKS, HOULTON, MAINE.	
5679	Buffalo 5-8-7	Limestone
5685	Buffalo 5-8-7	Houlton
5702	Buffalo 5-8-7	Ea. Newport
5686	Buffalo 4-8-4	Houlton
5684	Buffalo 4-8-7	Houlton
5760	Buffalo 4-8-7	Dover
5683	Buffalo 4-8-6	Houlton
5670	Buffalo 4-9-1	Houlton
5759	Buffalo 4-10-8	Dover
5703	Buffalo 3-9-1	Houlton
5758	Buffalo 3-9-1	Dover

Analysis of Fertilizer Samples, 1920.

Station number	Water	Nitrogen					Phosphoric Acid				Potash	
		As nitrate	As ammonia	Active	Total		Available		Total			
					Found	Guaranteed	Found	Guaranteed	Found	Guaranteed	Found	Guaranteed
5738	8.09	0.76	1.34	2.19	2.64	2.47	8.40	8.00	9.65	9.00	4.20	4.00
5751	9.35	0.70	1.10	2.77	3.00	2.47	8.63	8.00	9.69	9.00	4.18	4.00
5833	9.35	0.36	0.36	1.05	1.20	0.82	8.51	8.00	9.14	9.00	2.08	2.00
5664	9.07	1.62	1.16	3.02	4.03	4.11	8.11	8.00	9.16	9.00	7.28	7.00
5693	8.98	1.34	1.48	2.91	4.21	4.11	8.46	8.00	10.05	9.00	6.93	7.00
5810	14.01	1.16	1.32	3.35	3.51	3.29	9.49	10.00	10.60	11.00	------	------
5750	8.71	------	------	------	------	------	16.74	16.00	17.29	17.00	------	------
5766	8.32	------	------	------	------	------	17.09	16.00	17.69	17.00	------	------
5608	9.59	1.36	1.72	3.76	4.34	4.11	8.84	8.00	9.82	9.00	4.15	4.00
5663	10.66	0.76	1.30	3.62	4.22	4.10	8.58	8.00	9.02	9.00	7.49	7.00
5773	8.58	0.96	1.00	3.56	4.21	4.10	7.80	8.00	9.76	9.00	6.96	7.00
5662	9.88	0.54	1.38	2.98	3.48	3.29	8.34	8.00	10.43	9.00	4.43	4.00
5772	7.25	1.12	0.26	2.92	3.38	3.29	8.31	8.00	10.05	9.00	8.22	7.00
5774	9.13	0.38	1.24	------	3.69	3.29	8.86	9.00	10.16	10.00	1.48	1.00
5771	9.32	0.76	0.12	2.14	2.50	2.47	7.49	8.00	9.53	9.00	4.68	4.00
5775	7.30	------	0.14	1.42	1.86	1.64	8.02	9.00	11.85	10.00	1.16	1.00
5816	7.37	0.56	0.60	2.45	2.67	2.46	8.00	8.00	9.47	9.00	2.90	3.00
5747	7.21	0.76	0.62	2.85	3.01	3.28	8.30	8.00	9.56	9.00	3.58	4.00
5659	7.94	0.90	0.90	2.96	3.34	3.28	8.90	8.00	10.30	9.00	5.39	6.00
5814	9.11	0.10	0.12	0.78	0.88	0.82	10.48	10.00	11.94	11.00	------	------
5700	5.64	0.04	0.94	2.47	2.62	2.46	8.02	8.00	9.08	9.00	4.30	4.00
5745	7.88	------	0.10	0.96	1.09	0.82	10.47	10.00	11.55	11.00	1.15	1.00
5746	4.49	0.10	0.14	1.54	1.83	1.64	8.29	8.00	9.40	9.00	2.26	2.00
5656	10.01	0.74	1.70	2.93	3.09	3.28	8.06	8.00	8.54	9.00	3.99	4.00
5679	12.21	0.60	1.48	3.65	4.20	4.12	8.34	8.00	9.54	9.00	7.44	7.00
5685	19.06	0.80	1.24	3.85	4.38	4.12	8.64	8.00	9.86	9.00	7.34	7.00
5702	10.96	0.84	1.36	3.76	4.28	4.12	8.03	8.00	8.54	9.00	8.09	7.00
5686	10.18	0.78	1.04	2.96	3.35	3.29	8.24	8.00	10.91	9.00	4.44	4.00
5684	10.69	0.58	1.10	2.80	3.29	3.29	8.87	8.00	11.95	9.00	6.92	7.00
5760	10.48	0.74	0.88	3.05	3.42	3.29	8.47	8.00	11.63	9.00	7.19	7.00
5683	8.31	0.60	1.04	3.30	3.66	3.29	8.21	8.00	10.91	9.00	6.21	6.00
5670	6.34	0.70	1.14	2.89	3.36	3.29	9.85	9.00	13.47	10.00	1.26	1.00
5759	6.30	1.38	0.26	2.98	3.40	3.29	10.13	10.00	12.62	11.00	------	------
5703	11.20	0.44	0.76	2.43	2.76	2.50	9.71	9.00	11.29	10.00	1.34	1.00
5758	8.17	0.32	1.12	2.49	2.74	2.50	9.81	9.00	11.95	10.00	1.72	1.00

Descriptive List of Fertilizer Samples, 1920.

Station number.	Manufacturer, Place of Business and Brand	Sample taken at
	LISTERS AGRICULTURAL CHEMICAL WORKS, NEWARK N. J.	
5652	Lister's Buyers Choice Acid Phosphate	Portland
5647	Lister's Corn & Potato Fertilizer	Portland
5643	Lister's Eastern Pride Fertilizer	Portland
5609	Lister's 5-8-4 Fertilizer	Belfast
5602	Lister's 4-8-4	Searsport
5648	Lister's Grain & Grass Fertilizer	Portland
5653	Lister's High Grade Acid Phosphate	Portland
5598	Lister's High Grade Potato Fertilizer	Searsport
5642	Lister's King Bee Fertilizer	Portland
5612	Lister's Manure Potato Fertilizer	Belfast
5635	Lister's Squirrel Brand Fertilizer	Portland
5649	Lister's Standard Pure Superphosphate of Lime	Portland
5639	Lister's Success	Portland
	LITTLEFIELD & SONS CO., AUBURN ME.	
5719	Littlefield's Bone Meal	Auburn
	LOWELL FERTILIZER CO., BOSTON, MASS.	
5618	Lowell Animal Brand for all Crops 3½-10	Belfast
5722	Lowell Animal Brand 3-8-4	Belfast
5682	Lowell Bone Fertilizer 2-8-2	So. Berwick
5752	Lowell Bone Fertilizer 2-8-2	Unity
5776	Lowell Bone Fertilizer 2-8-2	Gardiner
5821	Lowell Empress Brand 1-10-1	Wells
5802	Lowell Empress Brand 1½-10	Wiscasset
5788	Lowell 5-8-7	Bangor
5834	Lowell 5-8-7	Portland
5724	Lowell 4-8-4	Belfast
5755	Lowell 4-8-4	Gardiner
5723	Lowell 4-8-7	Belfast
5721	Lowell 4-8-6	Belfast
5619	Lowell Potato Corn & Vegetable 5-8	Belfast
5757	Lowell 3½-10	Corinna
5756	Lowell 2-8-3	Corinna
5753	Lowell 2-8-2	Buckfield
	MANCHESTER, RENDERING CO., MANCHESTER, N. H.	
5826	Manchester Animal Brand Fertilizer	Berwick
	MORISON BROTHERS, BANGOR, ME.	
5794	Acid Phosphate	Brewer
5793	Morison Brothers' 5-8-7 Fertilizer	Brewer
5799	Morison Brothers' 5-8-7 Fertilizer	Bangor

Analysis of Fertilizer Samples, 1920.

Station number	Water	Nitrogen					Phosphoric Acid				Potash	
					Total		Available		Total			
		As nitrate	As ammonia	Active	Found	Guaranteed	Found	Guaranteed	Found	Guaranteed	Found	Guaranteed
5652	9.88	------	------	------	------	------	14.46	14.00	15.21	15.00	------	------
5647	8.63	0.54	0.64	1.72	1.83	1.65	8.27	8.00	9.03	9.00	3.28	3.00
5643	8.25	0.86	0.90	2.30	2.62	2.47	8.07	8.00	9.06	9.00	4.01	4.00
5609	9.79	1.30	1.66	3.76	4.22	4.11	8.85	8.00	9.79	9.00	4.34	4.00
5602	8.70	1.32	0.78	2.92	3.30	3.29	8.28	8.00	9.35	9.00	4.18	4.00
5648	9.80	------	------	------	------	------	12.60	12.00	12.97	13.00	2.25	2.00
5653	11.88	------	------	------	------	------	15.98	16.00	16.83	17.00	------	------
5598	8.75	1.46	1.28	3.67	4.17	4.11	8.30	8.00	9.47	9.00	7.03	7.00
5642	9.40	0.46	0.56	1.63	1.81	1.65	10.31	10.00	11.17	11.00	4.06	4.00
5612	8.14	0.88	1.46	3.21	3.56	3.29	7.96	8.00	9.57	9.00	6.28	6.00
5635	8.99	0.30	0.28	0.83	1.09	0.82	8.41	8.00	9.17	9.00	2.23	2.00
5649	8.77	0.50	0.89	2.38	2.76	2.47	9.53	9.00	10.90	10.00	2.45	2.00
5639	8.24	0.44	0.65	1.75	1.89	1.65	8.07	8.00	9.13	9.00	2.36	2.00
5719	3.00	------	------	------	2.00	1.25	--------	--------	26.99	28.00	------	------
5618	4.48	0.08	0.86	2.86	3.36	2.87	11.92	10.00	13.53	11.00	------	------
5722	5.48	0.08	0.82	2.39	2.57	2.46	7.63	8.00	8.55	9.00	3.54	4.00
5682	9.61	0.06	0.16	1.52	1.60	1.64	7.15	8.00	8.47	9.00	2.19	2.00
5752	--------	0.14	0.16	1.83	1.96	1.64	7.93	8.00	9.36	9.00	2.24	2.00
5776	4.82	0.14	0.14	1.55	1.68	1.64	7.31	8.00	9.20	9.00	1.80	2.00
5821	8.26	0.10	0.14	0.85	0.89	0.82	9.41	10.00	11.09	11.00	1.22	1.00
5802	5.69	------	0.38	1.41	1.70	1.23	10.50	10.00	12.58	11.00	------	------
5788	7.71	1.60	0.28	3.41	4.25	4.10	7.01	8.00	8.76	9.00	7.03	7.00
5834	8.02	1.84	0.46	3.65	4.15	4.10	7.46	8.00	9.60	9.00	5.59	7.00
5724	6.35	0.50	0.84	2.85	3.26	3.28	8.02	8.00	9.33	9.00	4.11	4.00
5755	8.22	0.56	0.86	3.10	3.38	3.28	8.98	8.00	10.18	9.00	4.09	4.00
5723	7.11	0.62	0.76	2.96	3.31	3.28	8.69	8.00	10.00	9.00	6.37	7.00
5721	6.14	0.70	1.00	3.28	3.42	3.28	8.10	8.00	9.32	9.00	6.14	6.00
5619	7.93	0.88	0.98	3.71	4.20	4.10	8.76	8.00	10.37	9.00	------	------
5757	4.56	------	0.88	2.44	2.93	2.87	10.45	10.00	13.62	11.00	------	------
5756	5.83	0.34	0.20	1.72	1.81	1.64	8.11	8.00	9.25	9.00	2.99	3.00
5753	5.09	0.12	0.18	1.81	1.94	1.64	7.58	8.00	9.00	9.00	2.18	2.00
5826	9.16	0.10	0.24	2.70	2.90	2.80	10.49	10.00	15.63	13.00	4.12	4.00
5794	12.81	------	------	------	------	------	17.32	16.00	17.47	--------	------	------
5793	9.45	0.88	1.00	3.72	4.19	4.11	9.31	8.00	10.10	9.00	7.44	7.00
5799	9.01	1.68	1.20	3.84	4.25	4.11	9.00	8.00	9.79	9.00	7.26	7.00

Descriptive List of Fertilizer Samples, 1920.

Station number.	Manufacturer, Place of Business and Brand	Sample taken at
5797	Morison Brothers' 4-8-4 Fertilizer	Ea. Corinth
5796	Morison Brothers' 4-6-10 Fertilizer	Ea. Corinth
5798	Morison Brothers' 3-10-3 Fertilizer	Bangor
5795	Nitrate of Soda	Bangor
	NATIONAL FERTILIZER CO., NEW YORK CITY.	
5594	National Aroostook Special Fertilizer	Searsport
5671	National Aroostook Special Fertilizer	Houlton
5614	National Complete Root & Grain Fertilizer	Belfast
5657	National Complete Root & Grain Fertilizer	Presque Isle
5786	National Market Garden Fertilizer	Lincoln
5603	National Pine Tree State Potato Fertilizer	Searsport
5658	National Pine Tree State Potato Fertilizer	Presque Isle
5610	National Premier Potato Manure	Belfast
5822	National 16% Plain Superphosphate	Eliot
5781	National XXX Fish & Potash	Lincoln Center
	NATIONAL GUANO CO., AURORA, ILL.	
5634	Sheep's Head Pulverized Sheep Manure	Portland
5769	Sheep's Head Pulverized Sheep Manure	Portland
	NATURE'S FERTILIZER CO., BYRON, ME.	
5699	Nature's Plant Food & Soil Rectifier	Ft. Fairfield
	NEW ENGLAND FERTILIZER CO., BOSTON, MASS.	
5742	New England Corn Phosphate	Dexter
5770	New England Corn Phosphate 2-8-2	Ea. Dixfield
5804	New England Corn Phosphate 2-8-2	Wiscasset
5696	New England 5-8-7	Ft. Fairfield
5726	New England 5-8-7	Unity
5731	New England 5-8-7	Presque Isle
5727	New England 4-8-4	Unity
5668	New England 4-8-7	Washburn
5725	New England 4-8-7	Unity
5660	New England 4-8-6	Limestone
5617	New England High Grade Potato Fertilizer (1919)	Belfast
5803	New England Standard Fertilizer for Grass & Grain 1-10-1	Wiscasset
5744	New England Superphosphate	Dexter
5728	New England Superphosphate 3-8-4	Unity
5743	New England 3½-10	Dexter
5805	New England 2-8-3 for Vegetables & Grain	Wiscasset
	PARMENTER & POLSEY FERTILIZER CO., BOSTON, MASS.	
5790	Parmenter & Polsey 5-8	Bangor

Analysis of Fertilizer Samples, 1920.

Station number	Water	Nitrogen					Phosphoric Acid				Potash	
		As nitrate	As ammonia	Active	Total		Available		Total		Found	Guaranteed
					Found	Guaranteed	Found	Guaranteed	Found	Guaranteed		
5797	8.37	1.86	0.84	2.99	3.33	3.28	7.99	8.00	9.35	9.75	6.59	4.00
5796	8.45	1.52	0.96	3.55	3.93	3.29	7.05	6.00	7.91	6.50	9.22	10.00
5798	10.79	0.88	0.44	2.47	2.92	2.47	10.69	10.00	11.39	11.00	3.10	3.00
5795	0.95	15.12	------	15.12	15.12	15.00	--------	--------	--------	--------	------	------
5594	8.85	1.46	1.26	3.84	4.28	4.11	8.30	8.00	9.48	9.00	6.85	7.00
5671	8.44	1.50	1.36	3.71	4.18	4.11	8.24	8.00	9.52	9.00	7.23	7.00
5614	8.69	0.88	1.44	3.08	3.46	3.29	8.22	8.00	9.60	9.00	6.31	6.00
5657	8.90	0.90	1.00	2.94	3.34	3.29	7.97	8.00	9.24	9.00	6.24	6.00
5786	9.76	0.92	0.86	2.66	2.79	2.47	8.20	8.00	9.22	9.00	4.21	4.00
5603	7.92	1.26	0.80	2.96	3.46	3.29	8.23	8.00	9.35	9.00	4.06	4.00
5658	8.49	1.18	0.88	2.96	3.33	3.29	8.08	8.00	9.30	9.00	4.07	4.00
5610	9.86	1.32	1.70	3.80	4.27	4.11	8.75	8.00	9.64	9.00	4.22	4.00
5822	9.52	------	------	------	------	------	16.36	16.00	17.02	17.00	------	------
5781	5.38	0.76	0.94	2.71	2.88	2.47	10.47	10.00	11.26	11.00	3.02	3.00
5634	7.58	------	------	------	2.71	2.25	--------	--------	2.28	1.25	2.85	1.50
5769	7.41	------	------	------	2.33	2.25	--------	--------	2.10	1.25	2.58	1.50
5699	0.13	------	------	------	------	------	--------	--------	0.38	0.23	------	------
5742	5.08	0.10	0.22	1.56	1.68	1.64	7.04	8.00	8.45	9.00	1.97	2.00
5770	5.53	0.06	0.12	1.68	1.88	1.64	8.54	8.00	9.27	9.00	1.83	2.00
5804	5.21	0.14	0.22	1.55	1.73	1.64	8.01	8.00	9.36	9.00	2.04	2.00
5696	7.40	0.82	1.24	3.69	4.15	4.10	8.50	8.00	9.94	9.00	6.79	7.00
5726	7.29	0.96	1.02	3.83	4.14	4.10	8.68	8.00	10.15	.900	6.48	7.00
5731	7.37	0.98	1.06	3.69	4.12	4.10	8.35	8.00	9.71	9.00	5.83	7.00
5727	7.49	0.30	1.06	------	3.06	3.28	8.56	8.00	9.54	9.00	3.43	4.00
5668	7.68	0.66	0.76	2.87	3.30	3.28	7.65	8.00	9.27	9.00	7.21	7.00
5725	6.49	0.80	0.80	3.00	3.32	3.28	8.11	8.00	10.00	9.00	6.79	7.00
5660	7.94	0.82	0.88	2.99	3.35	3.28	8.86	8.00	10.17	9.00	5.78	6.00
5617	8.41	0.68	0.56	3.05	3.71	3.28	10.87	10.00	12.63	11.00	------	------
5803	5.35	0.06	0.10	0.89	0.99	0.82	9.80	10.00	10.75	11.00	1.10	1.00
5744	6.85	1.96	0.46	2.44	2.73	2.46	8.32	8.00	9.43	9.00	4.12	4.00
5728	7.11	0.74	0.18	2.04	2.34	2.46	8.03	8.00	8.86	9.00	3.97	4.00
5743	5.51	------	0.88	2.33	2.72	2.87	11.04	10.00	13.81	11.00	------	------
5805	6.83	0.16	0.38	1.51	1.73	1.64	8.37	8.00	9.21	9.00	2.96	3.00
5790	7.20	1.06	1.24	3.65	4.00	4.10	8.10	8.00	9.11	9.00	------	------

Descriptive List of Fertilizer Samples, 1920.

Station number.	Manufacturer, Place of Business and Brand	Sample taken at
5674	Parmenter & Polsey 5-8-7	Houlton
5697	Parmenter & Polsey 5-8-7	Ft. Fairfield
5695	Parmenter & Polsey 4-8-6	Ft. Fairfield
5789	Parmenter & Polsey Plymouth Rock 3-8-4	Bangor
5840	Parmneter & Polsey 3½-10	So. Brewer
5839	Parmenter & Polsey 2-10	So. Brewer
	PORTLAND RENDERING CO., PORTLAND, MAINE.	
5706	Portland Organic Fertilizer 4-8-4	Portland
5705	Portland Organic Fertilizer 4-8-6	Portland
5777	Portland Organic Fertilizer 4-8-6	Danforth
5681	Portland Organic Fertilizer 3-8-4	Portland
5680	Portland Organic Fertilizer 3-8-2	Portland
5778	Portland Organic Fertilizer 3-8-2	Danforth
5704	Portland Organic Fertilizer 3½-10	Portland
	SAGADAHOC FERTILIZER CO., BOWDOINHAM, ME.	
5813	Dirigo Fertilizer	Bowdoinham
5846	Muriate of Potash	Gardiner
5754	Nitrate of Soda	Winthrop
5812	Sagadahoc 5-8-7 Fertilizer	Lewiston
5842	Sagadahoc 5-8-7 Fertilizer	Mars Hill
5763	Sagadahoc 4-8-4 Fertilizer	Pittsfield
5761	Sagadahoc 4-8-6 Fertilizer	Pittsfield
5762	Sagadahoc 3-10-3 Fertilizer	Pittsfield
5764	Sagadahoc 2-10-2 Fertilizer	Pittsfield
	VIRGINIA-CAROLINA CHEMICAL CO., NEW YORK CITY.	
5736	V. C. Champion Brand	Van Buren
5767	V. C. Double Owl Brand	Augusta
5844	V. C. Fox Brand	Buxton
5768	V. C. Owl Brand	Augusta
5845	V. C. Plow Brand	Buxton
	WHITMAN & PRATT RENDERING CO., BOSTON, MASS.	
5837	Whitman & Pratt's 4-8-4 Brand	Springvale
5820	Whitman & Pratt's 1-10	Berwick
5819	Whitman & Pratt's 3-8-3	Berwick
5818	Whitman & Pratt's 3-10	Berwick

Analysis of Fertilizer Samples, 1920.

Station number	Water	Nitrogen					Phosphoric Acid				Potash	
		As nitrate	As ammonia	Active	Total		Available		Total			
					Found	Guaranteed	Found	Guaranteed	Found	Guaranteed	Found	Guaranteed
5674	6.79	0.74	1.38	3.54	3.95	4.10	8.20	8.00	9.65	9.00	7.25	7.00
5697	7.46	0.92	1.16	3.75	4.18	4.10	8.51	8.00	10.05	9.00	6.54	7.00
5695	8.05	0.84	1.04	3.19	3.45	3.28	8.17	8.00	9.63	9.00	6.03	6.00
5789	6.21	0.26	1.04	2.62	2.88	2.46	7.98	8.00	9.09	9.00	3.91	4.00
5840	7.79	0.62	0.72	2.35	2.52	2.87	8.88	10.00	11.18	11.00	------	------
5839	6.36	------	0.60	1.30	1.48	1.64	9.70	10.00	11.55	11.00	------	------
5706	5.64	0.62	1.02	3.18	[illegible]	3.28	9.57	8.00	11.66	9.00	4.43	4.00
5705	5.74	0.58	1.02	3.52	3.66	3.28	9.26	8.00	11.47	9.00	6.75	4.00
5777	7.03	0.56	1.06	2.95	3.52	3.28	8.78	8.00	12.17	9.00	6.53	6.00
5681	5.70	0.64	0.64	2.47	2.63	2.46	8.59	8.00	9.81	9.00	3.93	4.00
5680	5.71	0.44	0.96	2.36	2.58	2.46	8.55	8.00	9.97	9.00	2.11	2.00
5778	6.55	0.68	0.94	2.55	2.79	2.46	8.56	8.00	10.18	9.00	2.17	2.00
5704	6.71	0.44	1.02	2.82	3.25	2.88	10.91	10.00	13.75	11.00	------	------
5813	16.77	0.54	0.40	0.94	1.17	1.00	7.81	6.00	9.19	8.00	1.26	1.00
5846	------	------	------	------	------	------	------	------	------	------	53.56	50.00
5754	0.40	14.92	------	14.92	14.92	14.00	------	------	------	------	------	------
5812	8.13	0.56	0.92	------	3.90	4.12	9.31	8.00	10.90	9.00	6.47	7.00
5842	7.64	1.56	1.10	3.96	4.16	4.12	6.66	8.00	8.81	9.00	7.61	7.00
5763	11.77	1.34	1.06	3.27	3.78	3.29	9.10	8.00	9.86	9.00	4.51	4.00
5761	10.12	2.02	0.44	3.45	3.64	3.29	8.42	8.00	9.43	9.00	6.78	6.00
5762	13.48	1.16	0.54	2.47	2.73	2.47	10.09	10.00	11.07	11.00	3.20	3.00
5764	15.85	1.24	0.14	1.99	2.15	1.65	10.34	10.00	10.95	11.00	2.71	2.00
5736	8.60	0.18	1.14	2.73	3.36	3.30	8.54	8.00	9.72	9.00	3.74	4.00
5767	9.33	0.34	1.50	3.27	3.64	3.30	8.67	8.00	9.60	9.00	5.29	6.00
5844	11.26	------	------	------	------	------	12.92	14.00	13.97	15.00	------	------
5768	8.50	0.66	0.50	1.68	1.83	1.65	7.88	8.00	8.21	9.00	3.24	3.00
5845	9.82	0.16	0.18	1.49	1.71	0.82	8.02	8.00	8.78	9.00	1.22	1.00
5837	7.88	1.40	0.36	3.23	3.63	3.29	7.70	8.00	10.62	9.00	5.21	4.00
5820	6.45	0.08	0.10	0.75	0.96	0.82	10.03	10.00	12.90	11.00	------	------
5819	9.08	0.90	0.26	2.20	2.78	2.46	8.23	8.00	11.24	9.00	2.70	3.00
5818	7.95	0.36	0.20	2.14	2.62	2.46	10.61	10.00	13.34	11.00	------	------

Table Showing the Results of Examination of Samples of Lime and Limestone Collected by the Inspectors in 1919-20.

Station number	Name of Maker	Brand	Calcium Oxide Per Cent	
			Found	Claimed
5835	Dominion Lime Company	Pulverized Agricultural Lime	53.84	52.00
5709	Rockland & Rockport Lime Company	R. R. Land Lime	61.62	60.00
5661	Smith & McDougal Lime Company	Agricultural Lime	38.18	39.20
5811	United States Gypsum Company	Ben Franklin Agricultural Gypsum (Land Plaster)	23.94	19.00

BORAX IN FERTILIZERS.

The large amount of loss due to borax carried in fertilizers in 1919 led to investigations by the Station. Preliminary results have been published in Bulletin 288. And the results of a rather extensive greenhouse investigation undertaken in cooperation with the seven Stations in the Northeastern group of States is practically ready for publication.

Early in 1920 the Commissioner of Agriculture prepared cards that were sent to all on the Department and Station mailing lists urging that in view of the borax trouble of the preceding year, farmers send samples to the Station for prompt examination for borax.

All the samples sent by correspondents and the official samples were tested for borax. In most cases they carried no appreciable amount of borax and in no instance was the amount large enough to have, in the light of the experiments above referred to, toxic effect. While growers should continue to send samples to the Station in accordance with the suggestion of the Commissioner of Agriculture, there is little likelihood that any commercial fertilizer will again be offered with appreciable amount of borax.

November, 1920

MAINE
AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE.
CHAS. D. WOODS, Director

ANALYSTS.

James M. Bartlett — **Elmer R. Tobey**
Roydon L. Hammond — **C. Harry White**

Official Inspections

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COMMERCIAL AGRICULTURAL SEEDS, 1920

CHAS. D. WOODS.

The Commissioner of Agriculture is the executive of the law regulating the sale of agricultural seeds in Maine. It is the duty of the Director of the Maine Agricultural Experiment Station to make analyses of the samples collected by the Commissioner, and to publish the results of the analyses together with the names of the persons from whom the samples were obtained, and such additional information as may seem advisable.

NOTE. All correspondence relative to the inspection laws should be addressed to the Bureau of Inspections, Department of Agriculture, Augusta, Maine.

COMMERCIAL AGRICULTURAL SEEDS, 1920

THE LAW REGULATING THE SALE OF AGRICULTURAL SEEDS

The first law regulating the sale of agricultural seeds was enacted by the Legislature of 1897. This has been revised by the Legislature of 1905, 1911 and 1919. The following are the sections of the greatest importance to the dealer and the user of seeds. The most important changes made by the Legislature of 1919 is the declaration of noxious seeds and the vitality or germination guaranty required under section 3. As provided for under the inspection law, the Commissioner of Agriculture has proclaimed a list of seeds that will for the present be considered as noxious. This list is given on pages 93 and 94

Section 2. The term "agricultural seed" as used in this chapter shall be held to include the seeds of alfalfa, barley, Canadian blue grass, Kentucky blue grass, brome grass, buckwheat, alsike clover, crimson clover, red clover, medium clover, white clover, field corn, Kaffir corn, meadow fescue flax, Hungarian, millet, oats, orchard grass, rape, redtop, rye, sorghum, timothy and wheat.

Section 3. Every lot or package of agricultural seed which is sold, distributed, transported, offered or exposed for sale, distribution or transportation for seed, in the state by any dealer in seed shall have affixed in a conspicuous place on the outside thereof, a plainly written or printed statement clearly and truly giving the name thereof and its minimum percentage of purity and freedom from foreign matter, together with the name and approximate amount of each kind of noxious weed seed contained therein, and also a guarantee of the germinating power of the seed and the date of the test for germination.

Section 12. For the purpose of this chapter an article shall be deemed to be adulterated:

In case of agricultural seed:

First. If its purity falls below its accompanying guaranty.

Second. If it contains the seed of any poisonous plant, or any kind or amount of weed seed other than the kinds or amounts represented in the statement required by section three of this chapter.

Third. If it, upon test of germination made within six months of the date of test in statement under the provisions of section three herein above, does not show the same germinating power given in said statement prescribed by the provisions of said section three. Provided said seed has been constantly kept under conditions not injurious to its germinating qualities, and that a margin of tolerance of five per cent shall be allowed.

List of Noxious Weed Seeds Arranged Alphabetically by Common Names.

Ball Mustard (Neslia paniculata)
Bitter Dock (Rumex obtusifolius)
Black Mustard (Brassica nigra)
Bladder Campion (Silene latifolia)
Blue Bur or Stickseed (Lappula echinta)
Blueweed (Echium vulgare)
Canada Thistle (Cirsium arvense)
Charlock (Brassica arvensis)
Chicory (Cichorium intybus)
Clover Dodder (Cuscuta species)
Clustered Dock (Rumex conglomeratus)
Common Darnel (Lolium temulentum)
Common Ragweed (Ambrosia artemisiifolia)
Common (Annual) Sow Thistle (Sonchus oleraceus)
Corn Cockle (Agrostemma githago)
Cow-herb (Saponaria vaccaria)
Daisy Fleabane (Erigeron ramosus)
Field Bindweed (Convolvulus arvensis)
Field Penny Cress (Thlaspi arvense)
Field (Perrenial) Sow Thistle (Sonchus arvensis)
False Flax (Camelina sativa)
Great Ragweed (Ambrosia trifida)
Indian Mustard (Brassica juncea)
Hare's-Ear Mustard (Conringia orientalis)
King devil weed (Hieracium pratense)
Night-flowering Catchfly (Silene noctiflora)
Orange hawk weed (Hieracium aurantiacum)
Ox-eye Daisy (Crysanthemum leucanthemum)
Perennial Ragweed (Ambrosia psilostachya)
Ribgrass (Plantago lanceolata)
Rutabaga (Brassica campestris)
Small-seeded False Flax (Camelina microcarpa)
Spiny-leaved or Prickly Sow Thistle (Sonchus asper)
Sweet scabious (Erigeron annuus)
Tumble Mustard (Sisymbrium altissimum)
White Champion (Lychnis alba)
Wild Carrot (Daucus carota)
Wild Oats (Avena fatua)
Wild Radish (Raphanus raphanistrum)
Yellow Dock (Rumex crispus)

List of Noxious Weed Seeds Arranged Alphabetically by Scientific Names. (Gray's Manual. 17th Edition, 1908).

Agrostemma githago. Corn Cockle.
Ambrosia artemisiifolia. Common Ragweed.
Ambrosia psilostachya. Perennial Ragweed.
Ambrosia trifida. Great Ragweed.
Avena fatua. Wild Oats.
Brassica arvensis. Charlock.
Brassica campestris. Rutabaga.
Brassica juncea. Indian Mustard.
Brassica nigra. Black Mustard.
Camelina microcarpa. Small-seeded False Flax.
Camelina sativa. False Flax.
Chrysanthemum leucanthemum. Ox-eye Daisy.
Cichorium intybus. Chicory.
Cirsium arvense. Canada Thistle.
Conringia orientalis. Hare's-Ear Mustard.
Convolvulus arvensis. Field Bindweed.
Cuscuta species. Clover Dodder.
Daucus carota. Wild Carrot.
Echium vulgare. Blueweed.
Erigeron annuus. Sweet scabious.
Erigeron ramosus. Daisy Fleabane.
Hieracium aurantiacum. Orange hawk weed.
Hieracium pratense. King devil weed.
Lappula echinta. Blue Bur or Stickseed.
Lychnis alba. White champion.
Lolium temulentum. Common Darnel.
Neslia paniculata. Ball Mustard.
Plantago lanceolata. Ribgrass.
Raphanus raphanistrum. Wild Radish.
Rumex conglomeratus. Clustered Dock.
Rumex crispus. Yellow dock.
Rumex obtusifolius. Bitter Dock.
Saponaria vaccaria. Cow-herb.
Silene Latifolia. Bladder Champion.
Silene notciflora. Night-flowering Catchfly.
Sisymbrium altissimum. Tumble Mustard.
Sonchus asper. Spiny-leaved or Prickly Sow Thistle.
Sonchus arvensis. Field (Perennial) Sow Thistle.
Sonchus oleraceus. Common (Annual) Sow Thistle.
Thlaspi arvense. Field Penny Cress.

EXPLANATION OF TABLES

The tables giving the analyses of the samples collected by the Commissioner of Agriculture during the year 1920 together with the so-called official samples sent in by dealers are given in the tables which follow. The seeds are arranged alphabetically by their common name, the samples are arranged alphabetically by the name of the town in which the sample was drawn. Each sample is reported on two pages.

The table at the left gives the Station number of the sample, the name of the town where the sample was taken, the name of the dealer from whom the sample was drawn and, when known, the source from which the dealer purchased.

The table on the right hand pages gives the Station number of the sample and the detailed guarantees and analyses. By means of the Station numbers the two tables are readily compared. On the right hand page the second column gives the guaranty of purity and the next column gives the percentage of purity as found by examination in the laboratory. The three following columns gives the impurities telling how much of them are inert matter, such as dirt, hulls, etc., how much are harmless seeds as clover and desirable grasses and how much of the impurities are undesirable weed seeds.

The first column under noxious seeds shows whether or not noxious seeds were declared. The next column shows whether noxious seeds were found and if so their common name and approximate number per pound. The law relative to the presence of noxious seeds is new and was not very generally followed by dealers.

The three last columns on the right hand page have to do with the viability of the seed. The first column under germination gives the guaranty as fixed by the dealer. The second column gives the results of the analysis for germination.

The last column gives what is called the actual value. The figures in this column were obtained by multiplying the purity as found by the germination as found. Of course this product is not strictly accurate for the purity is found by weight and the germination by count. But it gives an approximate idea as to what part of the seed as purchased can be hoped to produce actual plants of the desired kind.

Descriptive List of Official Seed Samples, 1920.

Station number.	Kind of Seed. Name and Place of Business of Retailer and Jobber.
	ALFALFA.
9350	Bangor. R. B. Dunning & Co. Albert Dickinson, Chicago, Ill.
9294	Van Buren. H. A. Gagnon. Stanford Seed Co., Inc., Binghamton, N. Y.
	ALSIKE CLOVER.
9078	Ashland. H. B. Bartlett & Co.
9231	Auburn. Oscar Holway Co. Albert Dickinson, Chicago, Ill.
9233	Auburn. Oscar Holway Co. Albert Dickinson, Chicago, Ill.
9324	Bangor. Bangor Farmers' Union. H. W. Doughton, Inc., Phil. N. Y., Syracuse
9340	Bangor. C. M. Conant Co. F. H. Brastow & Son, South Brewer
9331	Bangor. H. A. Dunning. Philadelphia Seed Co., Inc., Philadelphia, Pa
9332	Bangor. H. A. Dunning. Wm. S. Scarlett & Co., Baltimore, Md.
9352	Bangor. R. B. Dunning & Co. Albert Dickinson, Chicago, Ill.
9321	Bangor. Thompson Implement & Seed Co.
9248	Bath. Bath Grain Co. Whitney Eckstein Seed Co., Buffalo, N. Y.
9402	Belfast. Belfast Farmers' Union. N. Wertheimer & Son, Ligonier, Ind.
9400	Belfast. A. A. Howes & Co. Thos. W. Emerson Co., Boston, Mass.
9145	Biddeford. Biddeford Farmers' Union. N. Wertheimer & Sons, Ligonier, Ind.
9261	Bridgewater. Fred W. Snow. John Watson Co., Houlton, Maine
9263	Bridgewater. A. M. Stackpole. John Watson Co., Houlton, Maine
9254	Brunswick. Brunswick Farmers' Union. N. Wertheimer & Sons, Ligonier, Ind.
9342	Bucksport. R. C. Marks. R. B. Dunning Co., Bangor, Maine
9149	Calais. Calais Farmers' Union. N. Wertheimer & Sons, Ligonier, Ind.
9388	Camden. Camden Farmers' Union. N. Wertheimer & Sons, Ligonier, Ind.
9301	Caribou. Caribou Grange Store. Nungesser Dickinson Seed Co., N. Y.
9298	Caribou. James H. Glenn. Albert Dickinson Co., Chicago, Ill.
9303	Caribou. Mitton, Poland & Bishop. Craver Dickinson Seed Co. Inc., Buffalo, New York
9156	Danforth. H. H. Putnam. R. B. Dunning & Co., Bangor, Maine
9268	Fort Fairfield. Ames & Hacker. Albert Dickinson Co., Chicago, Ill.
9287	Fort Kent. Phillippe A. Roy. R. B. Dunning Co., Bangor, Maine
9036	Houlton. John Watson & Co.
9095	Houlton. John Watson & Co.

Results of Examination of Official Seed Samples, 1920.

Station number.	Purity: Guaranty. %	Purity: Found. %	Impurities: Inert Matter. %	Impurities: Harmless Seeds. %	Impurities: Weed Seeds. %	Noxious Seeds: Declared?	Noxious Seeds: Number Found in One Pound	Germination: Guaranty. %	Germination: Found. %	Germination: Actual Value.* %
9350	98.0	99.0	1.0	----	----	No	None.	90.0	89.8	88.9
9294	98.1	99.2	0.8	----	----	No	None.	92.0	86.0	85.3
9078	99.2	99.2	0.2	0.4	0.2	No	Night flowering catchfly 100.	90.0	89.3	88.6
9231	96.8	97.5	----	2.5	----	No	Night flowering catchfly 1000.	90.0	78.0	76.0
9233	98.7	98.7	----	1.3	----	Yes	Night flowering catchfly 500.	90.0	75.8	74.8
9324	94.5	92.5	----	7.5	----	Yes	Small false flax 1000, Night flowering catchfly 500.	00.0	84.9	78.5
9340	98.0	96.2	0.9	2.4	0.5	No	Night flowering catchfly 1300, Small False flax 600, Curled dock 300.	90.0	84.3	81.1
9331	97.5	97.1	----	2.9	----	No	Night flowering catchfly 3500, Curled dock 500.	83.0	87.5	84.9
9332	96.6	96.5	----	3.5	----	Yes	Night flowering catchfly 500, Curled dock 500, Small false flax 500.	84.0	88.5	85.4
9352	99.2	99.3	----	0.7	----	No	None.	90.0	85.8	85.2
9321	94.0	93.8	----	6.2	----	No	Night flowering catchfly 5000.	90.0	70.5	66.1
9248	97.0	96.8	----	3.2	----	No	Curled dock 500, Night flowering catchfly 500.	90.0	79.7	77.2
9402	99.0	97.4	----	2.6	----	No	Night flowering catchfly 1000.	97.0	87.1	84.8
9400	96.0	88.8	----	11.2	----	No	Night flowering catchfly 6500, Small false flax 2000, Ox-eye daisy 1000.	90.0	79.6	70.7
9145	98.0	98.2	----	1.8	----	No	Curled dock 500, Night flowering catchfly 500.	00.0	75.7	74.4
9261	97.0	97.7	----	2.3	----	No	Small false flax 1000, Night flowering catchfly 500.	90.0	80.2	78.4
9263	99.0	99.2	----	0.8	----	No	None.	92.0	91.0	90.2
9254	98.0	95.9	0.3	2.9	0.9	No	Curled dock 1200, Night flowering catchfly 500.	00.0	89.2	85.6
9342	95.0	95.8	----	4.2	----	No	Ribgrass 500.	00.0	76.1	72.9
9149	98.0	98.5	----	1.5	----	No	Night flowering catchfly 500.	00.0	79.1	77.9
9388	97.0	97.6	----	2.4	----	No	Night flowering catchfly 500.	00.0	77.5	75.6
9301	00.0	97.1	----	2.9	----	No	Night flowering catchfly 3500.	00.0	83.5	81.0
9298	97.5	97.6	----	2.4	----	Yes	Night flowering catchfly 1000, Small false flax 500.	95.0	82.9	80.9
9303	90.0	87.4	1.7	6.2	4.7	No	Night flowering catchfly 13900, Small false flax 600, Curled dock 400, Ribgrass 300, Ox-eye daisy 200.	90.0	69.0	60.3
9156	96.0	96.2	----	3.8	----	No	Night flowering catchfly 500, Small false flax 500, Curled dock 500.	90.0	80.2	77.2
9268	96.7	97.4	----	2.6	----	No	Night flowering catchfly 4500.	90.0	82.9	81.7
9287	96.0	96.2	----	3.8	----	Yes	Night flowering catchfly 1500.	90.0	79.4	76.4
9036	99.0	98.7	0.3	0.5	0.5	No	Ribgrass 300.	90.0	83.2	82.1
9095	99.0	99.2	0.1	0.4	0.3	No	Night flowering catchfly 600, Small false flax 200.	94.0	89.2	88.4

*Obtained by multiplying per cent purity by per cent germination.

Descriptive List of Official Seed Samples, 1920.

Station number.	Kind of Seed. Name and Place of Business of Retailer and Jobber.
9096	Houlton. John Watson & Co.
9113	Houlton. John Watson & Co.
9114	Houlton. John Watson & Co.
9306	Island Falls. Island Falls Grange Store. Oscar Holway Co., Auburn. Me.
9168	Lincoln. Lincoln Farmers' Union. Albert Dickinson Co., Chicago, Ill.
9266	Mars Hill. E. M. Smith. E. W. Conklin & Sons, Binghamton, N. Y.
9125	Monmouth. Highmoor Farm
9311	Pittsfield. Eastern Grain Co. Oscar Holway Co., Auburn, Me.
9273	Presque Isle. Aroostook Cooperative Store. Mitton, Poland & Bishop, Caribou, Maine
9120	Presque Isle. E. W. Fernald
9277	Presque Isle. E. W. Fernald. Craver Dickinson Seed Co., Buffalo, N. Y.
9280	Presque Isle. E. W. Fernald. H. W. Doughtman Inc., New York
9134	Saco. Scales Hardware Co. Kendall & Whitney, Portland, Maine
9408	Skowhegan. Skowhegan Farmers' Union. Kendall & Whitney, Portland, Me.
9292	Van Buren. H. A. Gagnon. Sanford Seed Co., Inc., Binghamton, N. Y.
9175	Westbrook. Westbrook Farmers' Union. Patron's Cooperative Corporation, Portland, Maine
9370	Wiscasset. Wiscasset Grain Co. Wm. G. Scarlett & Co., Baltimore
	BARLEY.
9339	Bangor. C. M. Conant Co. E. W. Conklin & Son. Binghamton, N. Y.
9314	Bangor. Thompson Implement & Seed Co. Oscar Holway Co., Auburn, Me.
9405	Belfast. Hall & Wilkins. Oscar Holway Co., Auburn, Maine
9401	Belfast. A. A. Howes & Co. Thos. W. Emerson Co., Boston, Mass.
9210	Berwick. A. D. Turgeon. Kendall & Whitney, Portland, Maine
9147	Biddeford. Andrews & Horrigan. Kendall & Whitney, Portland, Maine
9394	Camden. J. C. Curtis Co. Kendall & Whitney, Portland, Maine
9270	Fort Fairfield. S. Nightingale & Son. Stanford Seed Co., Inc., Albany, N. Y.
9215	Lewiston. E. P. Ham. Wm. G. Scarlett & Co., Baltimore, Md.
9220	Lewiston. E. P. Ham. Whitney Eckstein Seed Co., Buffalo, N. Y.
9214	Lewiston. Frank L. Heureux. Haskell Implement Co., Lewiston, Me.
9241	Norway. C. B. Cummings & Son Co. E. W. Conklin & Son, Binghamton, New York

Results of Examination of Official Seed Samples, 1920.

Station number.	Purity: Guaranty. %	Purity: Found. %	Impurities: Inert Matter. %	Impurities: Harmless Seeds. %	Impurities: Weed Seeds. %	Noxious Seeds: Declared?	Noxious Seeds: Number Found in One Pound	Germination: Guaranty. %	Germination: Found. %	Germination: Actual Value.* %
9096	97.0	97.2	0.4	1.8	0.6	No	Night flowering catchfly 1600, Small false flax 300, Curled dock 200, Canada thistle 100.	90.0	85.4	83.0
9113	99.0	98.8	0.1	0.9	0.2	No	Night flowering catchfly 400, Small false flax 100.	94.0	93.0	91.8
9114	97.0	96.2	0.3	2.6	0.9	No	Night flowering catchfly 1400.	90.0	89.4	86.0
9306	97.5	97.4	----	2.6	----	No	Night flowering catchfly 500.	95.0	86.4	84.2
9168	95.0	95.3	0.2	3.3	1.2	Yes	Night flowering catchfly 3000, Canada thistle 200.	00.0	84.4	80.4
9266	97.6	97.6	----	2.4	----	No	None.	85.0	83.5	81.5
9125	96.0	96.1	0.2	3.3	0.4	No	Night flowering catchfly 1500, Curled dock 100.	90.0	88.6	85.0
9311	96.1	96.7	----	3.3	----	No	Bitter dock 500.	90.0	71.8	69.4
9273	97.0	88.2	1.6	6.0	4.2	No	Night flowering catchfly 10500, Small false flax 1500, Ribgrass 1100, Ox-eye daisy 200, Curled dock 100.	90.0	68.6	60.5
9120	95.0	88.3	2.5	6.9	2.3	No	Night flowering catchfly 7300, Small false flax 2300, Ox-eye daisy 500, Bladder campion 400, Curled dock 200.	92.0	80.7	71.3
9277	95.0	92.9	1.0	5.1	1.0	No	Night flowering catchfly 1800, Small false flax 500, Ribgrass 400, Canada thistle 100.	91.0	68.2	61.4
9280	92.5	87.2	1.0	9.4	2.4	Yes	Night flowering catchfly 9500, Small false flax 300, Canada thistle 100, Ribgrass 100, Curled dock 100.	87.0	78.8	68.7
9134	95.0	95.5	0.3	3.3	0.9	No	Night flowering catchfly 2800.	90.0	82.4	78.7
9408	95.0	96.0	----	4.0	----	Yes	Night flowering catchfly 3500.	90.0	88.6	85.0
9292	96.0	96.6	----	3.4	----	No	Night flowering catchfly 5000, Curled dock 500.	90.0	82.2	79.4
9175	00.0	94.8	----	5.2	----	No	Small false flax 500, Clover dodder 500, Night flowering catchfly 2000.	90.0	86.2	81.7
9370	95.5	95.7	----	4.3	----	No	Night flowering catchfly 4000.	75.0	85.0	81.3
9339	98.0	98.2	0.5	1.2	----	No	None.	95.0	96.5	94.8
9314	96.0	96.6	0.1	3.2	----	No	None.	94.0	94.0	90.8
9405	98.5	98.0	0.8	1.0	0.04	No	None.	95.0	92.5	90.6
9401	98.0	99.1	0.4	----	----	No	None.	00.0	97.0	96.2
9210	97.0	97.6	0.5	1.8	----	No	None.	95.0	98.0	95.6
9147	99.0	97.0	0.7	2.1	----	No	None.	90.0	98.5	95.5
9394	98.0	95.9	1.0	3.0	0.02	No	None.	90.0	91.5	87.7
9270	00.0	96.7	0.7	2.5	0.04	No	None.	98.0	92.5	89.4
9215	97.9	98.7	0.7	0.5	----	No	None.	80.0	93.5	92.3
9220	98.0	96.0	0.4	2.8	----	No	None.	90.0	100.0	96.6
9214	98.6	95.7	0.9	3.2	----	No	Mustard 30.	96.0	91.0	87.1
9241	97.3	96.6	0.8	2.5	----	No	None.	95.0	96.5	93.2

*Obtained by multiplying per cent purity by per cent germination.

Descriptive List of Official Seed Samples, 1920.

Station number.	Kind of Seed. Name and Place of Business of Retailer and Jobber.
9138	Saco. Saco Grain & Milling Co. Whitney Eckstein Seed Co., Buffalo, N. Y.
9416	Skowhegan. E. L. & A. Gerald. Gerrish & Smith, Waterville, Maine
9383	Warren. A. & P. D. Starrett. Haskell Implement & Seed Co., Auburn
	BUCKWHEAT (India Wheat).
9338	Bangor. C. M. Conant Co.
9365	Bangor. R. B. Dunning & Co.
9322	Bangor. Thompson Implement & Seed Co. George E. Hanson, Bradford Center, Maine
	BUCKWHEAT (Japanese)
9253	Brunswick. J. B. Ham Co. Kendall & Whitney, Portland, Me.
9417	Skowhegan. E. L. & A. Gerald. Oscar Holway Co., Auburn, Maine
	BUCKWHEAT (Silver Hull)
9366	Bangor. R. B. Dunning & Co. Albert Dickinson Co., Chicago, Ill.
	CORN
9328	Bangor. Bangor Farmers' Union. Everett Peacock Co., Chicago, Ill.
9336	Bangor. C. M. Conant Co.
9337	Bangor. C. M. Conant Co. Everett B. Clark Seed Co., Milford, Conn.
9358	Bangor. R. B. Dunning & Co. W. H. Morehouse & Co., Toledo, Ohio
9359	Bangor. R. B. Dunning & Co. W. H. Morehouse & Co., Toledo, Ohio
9360	Bangor. R. B. Dunning & Co. W. H. Morehouse & Co., Toledo, Ohio
9361	Bangor. R. B. Dunning & Co. W. H. Morehouse & Co., Toledo, Ohio
9312	Bangor. Thompson Implement & Seed Co. S. D. Woodruff & Sons, New York
9313	Bangor. Thompson Implement & Seed Co. Whitney Eckstein Seed Co., Buffalo, N. Y.
9316	Bangor. Thompson Implement & Seed Co. Oscar Holway Co., Auburn, Me.
9245	Bath. Bath Grain Co.
9207	Berwick. J. A. Tibbetts. Jos. Breck & Son, 52 N. Market St., Boston, Mass.
9208	Berwick. J. A. Tibbetts. Jos. Breck & Son, 52 No. Market St., Boston, Mass.
9142	Biddeford. J. Bean & Son. Kendall & Whitney, Portland, Maine
9252	Brunswick. Tondieau Bros. Edmund Lebel, Portland Road, Brunswick, Me.
9392	Camden. J. C. Curtis Co. Kendall & Whitney, Portland, Maine
9225	Lewiston. J. B. Ham Co. Oscar Holway Co., Auburn, Maine
9410	Madison. E. L. Hight. Oscar Holway Co., Auburn, Maine
9411	Madison. E. L. Hight. Oscar Holway Co., Auburn, Maine
9265	Mars Hill. E. M. Smith. Jerome B. Rice Seed Co., Cambridge, N. Y.
9237	Norway. Norway Farmers' Union. Whitney Eckstein Seed Co., Buffalo, N. Y.
9380	Rockland. Main Seed & Horticulture Co. D. M. Ferry & Co., Detroit, Mich.
9186	Sanford. O. W. Brown & Son. E. W. Conklin & Son, Binghamton, N. Y.
9211	So. Berwick. R. B. Rideout. Kendall & Whitney, Portland, Maine
9180	Springvale. L. S. Bradford. E. W. Conklin & Sons, Binghamton, N. Y.
9382	Waldoboro. J. T. Gay. Whitney Eckstein Seed Co., Buffalo, N. Y.
9374	Wiscasset. Wiscasset Grain Co. Haskell Implement & Seed Co., Lewiston, Me.

Results of Examination of Official Seed Samples, 1920.

Station number.	PURITY: Guaranty. %	PURITY: Found. %	IMPURITIES: Inert Matter. %	IMPURITIES: Harmless Seeds. %	IMPURITIES: Weed Seeds. %	NOXIOUS SEEDS: Declared?	NOXIOUS SEEDS: Number Found in One Pound	GERMINATION: Guaranty. %	GERMINATION: Found. %	GERMINATION: Actual Value.* %
9138	98.0	97.0	0.1	2.8	----	No	None.	90.0	100.0	97.0
9416	98.0	96.8	0.7	2.4	----	No	None.	90.0	99.0	95.8
9383	99.0	96.3	0.6	3.0	----	No	None.	00.0	97.0	93.4
9338	99.0	99.0	0.6	0.2	0.03	No	None.	95.0	81.0	80.2
9365	99.0	97.4	1.8	----	0.64	No	Charlock 20, Ox-eye daisy 20.	98.0	90.0	87.7
9322	00.0	99.2	----	0.5	0.15	No	None.	00.0	58.5	58.0
9253	97.0	99.8	0.2	----	----	No	None.	90.0	97.0	96.8
9417	98.1	97.8	0.9	0.8	0.45	No	Ragweed 510.	88.5	93.0	90.9
9366	98.0	99.4	0.4	----	----	No	Ragweed 10.	87.0	41.0	40.7
9328	90.0	100.0	----	----	----	No	None.	99.0	98.0	98.0
9336	99.0	100.0	----	----	----	No	None.	90.0	90.0	90.0
9337	98.0	100.0	----	----	----	No	None.	90.0	90.0	90.0
9358	99.0	100.0	----	----	----	No	None.	95.0	96.0	96.0
9359	99.0	100.0	----	----	----	No	None.	91.0	94.0	94.0
9360	99.0	100.0	----	----	----	No	None.	93.0	93.5	93.5
9361	99.0	100.0	----	----	----	No	None.	83.0	85.0	85.0
9312	98.0	100.0	----	----	----	No	None.	85.0	87.0	87.0
9313	98.0	100.0	----	----	----	No	None.	90.0	99.5	99.5
9316	99.8	100.0	----	----	----	No	None.	92.0	91.0	91.0
9245	98.9	100.0	----	----	----	No	None.	83.0	70.0	70.0
9207	95.0	100.0	----	----	----	No	None.	85.0	90.5	90.5
9208	98.0	100.0	----	----	----	No	None.	80.0	86.5	86.5
9142	00.9	99.2	0.7	----	----	No	None.	90.0	81.0	80.3
9252	00.0	100.0	----	----	----	No	None.	00.0	96.5	96.5
9392	00.0	100.0	----	----	----	No	None.	85.0	88.5	88.5
9225	99.8	100.0	----	----	----	No	None.	97.0	98.5	98.5
9410	99.8	100.0	----	----	----	No	None.	97.0	94.5	94.5
9411	99.5	100.0	----	----	----	No	None.	92.0	86.5	86.5
9265	00.9	100.0	----	----	----	No	None.	00.0	96.5	96.5
9237	98.0	100.0	----	----	----	No	None.	90.0	85.0	85.0
9380	00.0	100.0	----	----	----	No	None.	00.0	82.5	82.5
9186	98.7	100.0	----	----	----	No	None.	87.0	93.5	93.5
9211	00.0	100.0	----	----	----	No	None.	90.0	90.0	90.0
9180	98.7	100.0	----	----	----	No	None.	87.0	96.0	96.0
9382	98.0	98.5	1.5	----	----	No	None.	90.0	70.5	69.4
9374	99.8	100.0	----	----	----	No	None.	86.0	89.5	89.5

*Obtained by multiplying per cent purity by per cent germination.

Descriptive List of Official Seed Samples, 1920.

Station number.	Kind of Seed. Name and Place of Business of Retailer and Jobber.
	CRESTED DOG'S TAIL.
9353	Bangor. R. B. Dunning & Co. Nungesser Dickinson Co., New York
	ENGLISH RYE GRASS.
9351	Bangor. R. B. Dunning & Co. Nungesser Dickinson Co., N. Y.
	HUNGARIAN.
9234	Auburn. Oscar Holway Co. Illinois Seed Co., Chicago, Ill.
9327	Bangor. Bangor Farmers' Union. N. Wertheimer & Sons, Ligonier, Ind.
9333	Bangor. H. A. Dunning. Wm. G. Scarlett, Baltimore, Md.
9315	Bangor. Thompson Implement & Seed Co. Whitney Eckstein Seed Co., Buffalo
9247	Bath. Bath Grain Co. Whitney Eckstein Seed Co., Buffalo, N. Y.
9404	Belfast. Belfast Farmers' Union. R. B. Dunning Co., Bangor, Maine
9398	Belfast. A. A. Howes & Co. Thos. W. Emerson Co., Boston, Mass.
9209	Berwick. A. D. Turgeon. Kendall & Whitney, Portland, Maine
9152	Calais. Calais Farmers' Union. N. Wertheimer & Son, Ligonier, Ind.
9195	Kennebunk. George E. Cousens. Kendall & Whitney, Portland, Maine
9202	Kennebunk. George W. Larrabee & Co.
9217	Lewiston. Napoleon Beuregard. Haskell Implement & Seed Co., Lewiston
9227	Lewiston. J. B. Ham Co. Whitney Eckstein Seed Co., Buffalo, N. Y.
9412	Madison. E. L. Hight. Whitney Eckstein Seed Co., Buffalo, N. Y.
9235	Norway Lake. Norway Lake Supply Co. Illinois Seed Co., Chicago, Ill.
9185	Sanford. O. W. Brown & Son. E. W. Conklin & Son, Binghamton, N. Y.
9177	Springvale. W. H. Sherburne. Kendall & Whitney, Portland, Maine
	JAPANESE MILLET.
9334	Bangor. H. A. Dunning. C. M. Conant Co., Bangor, Maine
9396	Belfast. A. A. Howes & Co. Thomas W. Emerson Co., Boston, Mass.
9150	Calais. Calais Farmers' Union. N. Wertheimer & Sons, Ligonier, Ind.
9389	Camden. Camden Farmers' Union. N. Wertheimer & Sons, Ligonier, Ind.
9393	Camden. J. C. Curtis Co. Kendall & Whitney, Portland, Maine
9196	Kennebunk. George E. Cousens. Kendall & Whitney, Portland, Maine
9198	Kennebunk. George W. Larrabee & Co. Jos. Breck & Son, Boston, Mass.
9224	Lewiston. J. B. Ham Co. Whitney Eckstein Seed Co., Buffalo, N. Y.
9222	Lewiston. Haskell Implement & Seed Co. E. W. Conklin & Son Inc., Binghamton, N. Y.
9169	Lincoln. Lincoln Farmers' Union. Albert Dickinson Co., Chicago, Ill.
9148	Portland. Allen, Sterling & Lothrop. E. W. Conklin, Binghamton, N. Y.
9378	Rockland. L. N. Littlehale Co. Whitney Eckstein Seed Co., Buffalo, N. Y.
9139	Saco. Saco Grain & Milling Co. Nungesser Dickinson Seed Co., New York
9183	Sanford. O. W. Brown & Son. Kendall & Whitney, Portland, Maine
9419	Skowhegan. E. L. & A. Gerald. Gerrish & Smith, Waterville, Maine
9242	South Paris. B. D. Bolster Co. W. H. Morehouse & Co., Toledo, Ohio

Results of Examination of Official Seed Samples, 1920.

	PURITY		IMPURITIES			NOXIOUS SEEDS		GERMINATION		
Station number.	Guaranty.	Found.	Inert Matter.	Harmless Seeds.	Weed Seeds.	Declared?	Number Found in One Pound	Guaranty.	Found.	Actual Value.*
	%	%	%	%	%			%	%	%
9353	97.0	97.4	----	2.6	----	No	Spring sow thistle 2000, Ribgrass 1000.	91.0	15.0	14.6
9351	95.0	98.2	----	1.8	----	No	None.	90.0	77.5	76.1
9234	97.9	98.0	----	2.0	----	No	None.	90.0	84.5	82.8
9327	95.0	98.2	----	1.8	----	No	None.	00.0	88.0	86.4
9333	97.4	98.9	----	1.2	----	No	None.	84.5	68.0	67.1
9315	97.0	98.9	----	1.1	----	No	None.	85.0	82.5	81.5
9247	97.0	97.9	----	2.1	----	No	None.	90.0	92.0	90.0
9404	99.6	99.5	----	0.5	----	No	None.	95.0	96.0	95.5
9398	97.0	97.7	----	2.3	----	No	None.	86.0	75.5	73.7
9209	97.0	99.0	1.0	----	----	No	None.	90.0	82.5	81.6
9152	95.0	98.9	1.1	----	----	No	None.	00.0	91.0	90.0
9195	98.0	98.3	----	1.7	----	No	None.	82.0	88.5	87.0
9202	00.0	99.2	----	0.8	----	No	None.	00.0	11.0	10.9
9217	99.0	99.0	----	1.0	----	No	Ragweed 500.	92.0	90.5	89.6
9227	98.0	98.2	----	1.8	----	No	None.	90.0	94.5	92.8
9412	97.0	98.3	----	1.7	----	No	None.	90.0	90.0	88.4
9235	98.3	98.7	----	1.3	----	No	None.	90.0	87.0	85.8
9185	99.7	99.6	----	0.4	----	No	None.	92.0	89.5	89.1
9177	98.7	99.0	----	1.0	----	No	None.	82.0	83.5	82.6
9334	97.2	97.5	----	2.5	----	No	None.	90.0	91.0	88.7
9396	98.0	98.2	0.1	----	1.7	No	Ragweed 1100.	92.0	92.5	90.8
9150	90.5	96.6	0.8	9.2	2.4	No	Ragweed 800.	00.0	82.0	79.2
9389	00.0	96.5	----	3.5	----	No	None.	00.0	84.5	81.5
9393	90.0	97.8	----	2.2	----	No	None.	85.0	59.5	58.1
9196	90.0	98.8	----	1.2	----	No	None.	82.0	65.0	64.2
9198	99.0	97.4	0.1	----	2.5	No	Ragweed 500.	92.0	91.0	88.6
9224	98.0	99.0	----	1.0	----	No	None.	80.0	82.5	81.6
9222	97.2	97.7	----	2.3	----	Yes	Ragweed 1000.	80.0	82.5	80.6
9169	97.0	99.0	----	1.0	----	Yes	None.	75.0	61.0	60.3
9148	97.5	98.4	----	1.6	----	No	Ragweed 500.	75.0	56.5	55.6
9378	97.0	99.0	----	1.0	----	No	None.	85.0	84.5	83.6
9139	82.0	99.4	0.3	----	0.3	No	Ragweed 400.	90.2	91.0	90.4
9183	97.0	98.4	----	1.6	----	Yes	None.	75.0	80.0	78.7
9419	00.0	98.6	----	1.4	----	No	None.	0.00	92.5	91.2
9242	94.0	98.1	0.4	0.1	1.4	No	Ragweed 300.	86.0	54.0	52.9

*Obtained by multiplying per cent purity by per cent germination.

Descriptive List of Official Seed Samples, 1920.

Station number.	Kind of Seed. Name and Place of Business of Retailer and Jobber.
	MAMMOTH CLOVER.
9347	Bangor. R. B. Dunning & Co. Albert Dickinson, Chicago, Ill.
9098	Houlton. John Watson Co.
9105	Houlton. John Watson Co.
	OATS.
9356	Bangor. R. B. Dunning & Co. Ralph Copeland, Orono, Maine
9259	Bath. Bath Grain Co. Paris Flouring Co., Portland, Maine
9406	Belfast. Hall & Wilkins. William Donahue Co., Boston, Mass.
9141	Biddeford. J. Bean & Son. Kendall & Whitney, Portland, Maine
9395	Camden. J. C. Curtis Co. Kendall & Whitney, Portland, Maine
9393	Camden. H. H. Stover Co.
9281	Fort Kent. Fred Micheaud. E. W. Conklin & Son, Binghamton, N. Y.
9197	Kennebunk. G. W. Larrabee & Co. Joseph Breck & Sons, Boston, Mass.
9218	Lewiston. Napoleon Beaurregard. Haskell Seed & Implement Co., Lewiston, Me.
9216	Lewiston. Frank L. Heureux. J. B. Ham, Lewiston, Maine
9413	Madison. E. L. Hight. Merrill & Mayo Co., Waterville, Maine
9309	Pittsfield. Eastern Grain Co. Casco Grain Co.
9369	Portland. Patron's Cooperative Corporation. Illinois Seed Co.
9275	Presque Isle. Aroostook Cooperative Store. Oscar Holway Co., Auburn, Me.
9376	Rockland. G. H. Hart. Oscar Holway Co., Auburn, Maine
9184	Sanford. O. W. Brown & Son. Kendall & Whitney, Portland, Maine
9179	Springvale. L. S. Bradford. Joseph Breck & Sons, Boston, Mass.
	ORCHARD GRASS.
9364	Bangor. R. B. Dunning & Co. Nungesser Dickinson Co., New York
9318	Bangor. Thompson Implement & Seed Co. William F. Chick, Bangor
	RAPE.
9251	Bath. Pine Tree State Seed Co. Whitney Eckstein Seed Co., Buffalo, N. Y.
9140	Biddeford. Andrews & Horrigan. Kendall & Whitney, Portland, Maine
9191	Kennebunk. George E. Cousens. Kendall & Whitney, Portland, Maine
9185	Sanford. S. J. Nowell. Joseph Breck & Son, Boston, Mass.
9409	Skowhegan. Skowhegan Farmers' Union. T. W. Wood & Sons, Richmond, Va.
	RED CLOVER.
9079	Ashland. H. B. Bartlett & Co.
9230	Auburn. Oscar Holway Co. Albert Dickinson, Chicago, Ill.
9232	Auburn. Oscar Holway Co. Albert Dickinson, Chicago, Ill.
9339	Bangor. Herbert A. Dunning. Philadelphia Seed Co. Inc., Philadelphia, Pa.
9346	Bangor. R. B. Dunning & Co. Albert Dickinson, Chicago, Ill.
9349	Bangor. R. B. Dunning & Co. Albert Dickinson, Chicago, Ill.
9329	Bangor. Thompson Implement & Seed Co. Whitney Eckstein Seed Co., Buffalo
9246	Bath. Bath Grain Co. Whitney Eckstein Seed Co., Buffalo, N. Y.
9403	Belfast. Belfast Farmers' Union. N. Wertheimer & Sons, Ligonier, Ind.

Results of Examination of Official Seed Samples, 1920.

Station number.	Purity: Guaranty. %	Purity: Found. %	Impurities: Inert Matter. %	Impurities: Harmless Seeds. %	Impurities: Weed Seeds. %	Noxious Seeds: Declared?	Noxious Seeds: Number Found in One Pound	Germination: Guaranty. %	Germination: Found. %	Germination: Actual Value.* %
9347	99.7	99.7	0.1	0.1	0.1	No	Bitter dock 200.	94.0	88.6	88.3
9098	99.5	99.6	0.2	0.1	0.1	No	Curled dock 100.	92.0	91.5	91.1
9108	99.0	99.2	0.3	0.3	0.2	No	None.	92.0	95.6	94.9
9356	99.0	98.8	0.6	0.1	0.3	No	None.	95.0	97.0	95.8
9250	00.0	98.8	1.0	----	----	No	Black mustard 130, Curled dock 20.	00.0	95.0	93.9
9406	00.0	97.5	2.1	0.3	----	No	Mustard 10.	00.0	95.5	93.1
9141	99.0	96.1	0.2	3.5	0.07	No	Ball mustard 10.	97.0	99.0	95.1
9395	99.0	95.9	0.2	3.7	0.22	No	Ball mustard 10.	98.0	96.0	92.1
9399	00.0	98.9	0.8	0.1	0.23	No	Curled dock 50, Mustard 10.	00.0	98.5	97.4
9281	97.4	97.5	0.7	1.6	0.01	No	None.	98.0	99.5	97.0
9197	99.0	99.2	0.3	0.4	0.05	No	None.	98.0	95.5	94.7
9218	98.0	99.0	0.9	----	----	No	None.	95.0	81.5	79.7
9216	97.0	97.5	0.2	2.1	----	No	None.	00.0	97.0	94.6
9413	99.6	96.9	1.1	1.5	0.08	No	None.	99.0	95.0	92.1
9309	00.0	94.0	2.8	3.0	0.01	No	Mustard 10.	00.0	92.0	86.5
9369	99.7	99.7	0.1	----	----	No	None.	97.0	95.5	95.2
9275	00.0	98.4	1.2	0.3	----	No	Mustard 10.	0.00	97.0	95.5
9376	96.3	97.9	1.2	0.8	0.1	No	None.	96.0	93.5	91.5
9184	98.7	99.3	0.6	--	----	No	None.	95.5	96.0	95.3
9179	90.0	97.9	0.7	1.3	----	No	None.	90.0	99.0	96.9
9364	75.0	82.6	----	17.4	----	No	None.	85.0	76.0	62.7
9318	83.0	82.8	----	17.2	----	No	Bitter dock 2000.	00.0	49.0	40.5
9251	98.0	99.6	----	----	----	No	None.	90.0	95.5	95.1
9146	98.0	99.7	0.2	----	----	No	None.	00.0	93.5	93.2
9191	99.0	99.8	0.2	--	----	No	None.	80.0	83.5	83.3
9188	98.0	99.8	----	--	----	No	None.	00.0	85.0	84.8
9409	90.0	99.9	----	0.1	----	No	Night flowering catchfly 50.	80.0	79.5	79.4
9079	99.1	99.2	0.3	0.2	0.3	No	Night flowering catchfly 100.	92.0	92.0	91.2
9230	98.5	98.7	----	1.3	.	No	Curled dock 500, Wild carrot 500.	92.5	92.0	90.8
9232	98.5	99.0	----	1.0	----	No	Ribgrass 500, Wild carrot 500.	80.0	80.5	79.7
9330	99.2	99.4	-	0.6	-	No	None.	86.0	92.8	92.2
9346	99.4	99.4	0.1	0.4	.1	No	None.	93.0	92.3	91.7
9246	98.0	98.0	----	2.0	----	Yes	Ribgrass 4500.	85.0	84.5	79.4
9320	98.0	98.1	----	1.9	----	No	Ribgrass 2000.	90.0	92.0	90.2
9246	98.0	98.0	----	2.0	----	No	Ribgrass 1500, chicory 500, wild carrot 500.	90.0	93.9	92.0
9403	99.0	98.2	----	1.8	----	No	Ribgrass 2500, wild carrot 1000.	93.0	88.3	86.7

*Obtained by multiplying per cent purity by per cent germination.

Descriptive List of Official Seed Samples, 1920.

Station number.	Kind of Seed. Name and Place of Business of Retailer and Jobber.
9399	Belfast. A. A. Howes & Co. Thos. W. Emerson Co., Boston, Mass.
9255	Brunswick. Brunswick Farmers' Union. N. Wertheimer & Sons, Ligonier, Ind.
9344	Bucksport. R. C. Marks. R. B. Dunning & C.o, Bangor, Maine
9151	Calais. Calais Farmers' Union. N. Wertheimer & Son, Ligonier, Ind.
9387	Camden. Camden Farmers' Union. N. Wertheimer & Sons, Ligonier, Ind.
9299	Caribou. Caribou Grange Store. Nungesser Dickinson Seed Co., New York
9297	Caribou. James H. Glenn. Albert Dickinson, Chicago, Ill.
9304	Caribou. Mitton, Poland & Bishop. Albert Dickinson, Chicago, Ill.
9302	Caribou. W. C. Spaulding. R. B. Dunning & Co., Bangor, Maine
9154	Danforth. H. H. Putnam. R. B. Dunning & Co., Bangor, Maine
9157	Danforth. H. H. Putnam. C. M. Conant Co., Bangor, Maine
9271	Fort Fairfield. S. Nightingale & Son. Stanford Seed Co. Inc., Albany, N. Y.
9282	Fort Kent. Fred Michaurd. Wm. G. Scarlett & Co., Baltimore, Md.
9284	Fort Kent. G. H. Page. The Stanford Seed Co. Inc. Binghamton
9286	Fort Kent. Philippe A. Roy. R. B. Dunning & Co., Bangor, Maine
9037	Houlton. John Watson & Co.
9097	Houlton. John Watson & Co.
9099	Houlton. John Watson & Co.
9112	Houlton. John Watson & Co.
9308	Island Falls. Island Falls Grange Store. Oscar Holway Co., Auburn, Me.
9192	Kennebunk. George E. Cousens. Kendall & Whitney, Portland, Maine
9201	Kennebunk. George W. Larrabee Co. Joseph Breck & Son, Boston, Mass.
9223	Lewiston. J. B. Ham Co. Milwaukee Seed Co., Milwaukee, Wis.
9226	Lewiston. J. B. Ham Co. Whitney Eckstein Seed Co., Buffalo, N. Y.
9267	Mars Hill. E. M. Smith. E. W. Conklin & Son, Binghamton, N. Y.
9127	Monmouth. Highmoor Farm
9249	Norway. C. B. Cummings & Sons Co. Haskell Seed & Implement Co., Lewiston
9310	Pittsfield. Eastern Grain Co. Oscar Holway Co., Auburn, Maine
9274	Presque Isle. Aroostook Cooperative Store. Mitton, Poland & Bishop, Caribou
9119	Presque Isle. E. W. Fernald
9276	Presque Isle. E. W. Fernald. Albert Dickinson, Chicago, Ill.
9278	Presque Isle. E. W. Fernald. H. W. Doughten Inc. Philadelphia, N. Y., Syracuse
9279	Presque Isle. E. W. Fernald. W. H. Small
9135	Saco. Scales Hardware Co. Kendall & Whitney, Portland, Maine
9415	Skowhegan. Steward & Smiley. Oscar Holway Co., Auburn, Maine
9293	Van Buren. H. A. Gagnon. Stanford Seed Co. Inc., Binghamton, N. Y.

Results of Examination of Official Seed Samples, 1920.

	Purity		Impurities			Noxious Seeds		Germination		
Station number.	Guaranty. %	Found. %	Inert Matter. %	Harmless Seeds. %	Weed Seeds. %	Declared?	Number Found in One Pound	Guaranty. %	Found. %	Actual Value.* %
9399	98.0	98.2	----	1.8	----	No	None.	85.0	96.5	94.7
9255	99.0	99.2	----	----	----	No	Ribgrass 1500.	00.0	91.0	90.2
9344	98.0	98.2	----	1.8	----	No	Ribgrass 2000, chicory 500, wild carrot 500.	00.0	46.3	45.4
9151	99.0	98.6	0.3	0.1	1.0	No	Ribgrass 2900, wild carrot 300, chicory 100.	00.0	80.9	79.7
9387	93.0	98.0	----	2.0	----	No	Ribgrass 3500, wild carrot 500.	00.0	82.0	80.3
9299	00.0	98.8	----	1.2	----	No	None.	00.0	82.5	81.5
9297	98.0	97.7	----	2.3	----	No	Ribgrass 500.	85.0	77.9	76.1
9304	95.1	98.3	----	1.7	----	No	Wild carrot 2500, curled dock 500.	85.0	90.6	89.0
9302	97.5	98.0	----	2.0	----	Yes	Ribgrass 1500.	90.0	86.8	85.0
9154	97.3	97.5	----	2.5	----	No	Curled dock 500, ragweed 500, black mustard 500.	90.0	86.5	84.3
9157	99.5	99.5	----	----	----	No	None.	92.0	91.6	91.1
9271	99.5	99.2	----	----	----	No	None.	92.0	85.1	84.6
9282	98.1	98.7	----	----	----	Yes	Ribgrass 1500.	90.0	90.8	89.6
9284	97.0	97.8	----	----	----	No	None.	90.0	82.3	80.4
9286	97.3	97.5	0.7	0.6	1.2	No	Curled dock 500, ribgrass 300.	90.0	73.9	72.1
9037	99.0	99.1	0.3	0.1	0.5	No	None.	90.0	81.5	80.7
9097	99.0	99.5	0.2	0.2	0.1	No	None.	92.0	84.1	83.7
9099	98.5	98.7	0.6	0.2	0.6	No	Wild carrot 100, chicory 100.	90.0	85.0	84.3
9112	98.5	98.8	0.4	0.7	0.1	No	Wild carrot 100.	90.0	90.0	88.7
9308	98.5	98.6	----	----	----	No	Wild carrot 2500, ribgrass 2000.	92.5	90.0	88.7
9192	98.9	99.0	----	----	----	No	Ribgrass 1500, wild carrot 1000.	90.0	78.5	77.7
9201	00.0	97.9	0.7	0.8	0.6	No	Ribgrass 200, wild carrot 100, common sow thistle 100.	00.0	72.6	71.1
9223	99.0	84.6	3.0	3.8	8.6	No	Ribgrass 1600, curled dock 900, wild carrot 400, night flowering catchfly 300, bladder campion 200.	95.0	71.0	60.0
9226	98.0	98.4	----	----	----	No	Wild carrot 2000, ribgrass 1500, chicory 500.	90.0	91.8	90.3
9267	99.3	99.5	----	0.5	----	No	None.	90.0	91.5	91.0
9127	99.2	99.1	0.1	0.2	0.6	No	None.	94.0	92.4	91.6
9240	99.0	97.7	0.3	0.5	1.5	Yes	Ribgrass 1600.	89.0	73.6	71.9
9310	98.2	98.8	----	1.2	----	No	None.	80.0	85.1	84.1
9274	98.0	99.0	----	----	----	No	Wild carrot 2500.	92.0	91.0	90.0
9119	97.0	96.9	0.3	----	2.6	No	None.	91.0	92.6	89.7
9276	98.0	98.3	----	----	----	No	Wild carrot 3500, ribgrass 1000.	00.0	91.5	89.9
9278	98.5	98.6	----	----	----	No	None.	92.0	84.1	82.9
9279	97.0	97.2	1.6	0.2	1.0	Yes	Curled dock 200, ribgrass 100, ragweed 100.	91.0	82.8	80.4
9135	98.7	97.6	0.9	0.4	1.1	No	Ribgrass 900, ragweed 300.	90.0	77.8	75.9
9415	97.5	98.5	----	----	----	No	None.	85.0	87.6	86.3
9293	98.0	99.0	----	----	----	No	None.	90.0	88.5	87.6

*Obtained by multiplying per cent purity by per cent germination.

Descriptive List of Official Seed Samples, 1920.

Station number.	Kind of Seed. Name and Place of Business of Retailer and Jobber.
9295	Van Buren. Jos. Martin & Sons. Chicago Seed Co., Chicago, Ill.
9296	Van Buren. Jos. Martin & Sons. Milwaukee Seed Co., Milwaukee, Wis.
9384	Warren. A. & P. D. Starrett.
9174	Westbrook. Westbrook Farmers' Union. Patron's Cooperative Corporation, Portland, Maine.
9371	Wiscasset Grain Co. Wm. G. Scarlet & Co., Baltimore, Md.
	RED FESCUE.
9355	Bangor. R. B. Dunning & Co. Nungesser Dickinson Co., New York.
	REDTOP.
9229	Auburn. Oscar Holway Co. Albert Dickinson, Chicago, Ill.
9326	Bangor. Bangor Farmers' Union. N. Wertheimer & Sons, Ligonier, Ind.
9341	Bangor. C. M. Conant Co. Whitney Eckstein Co., Buffalo, N. Y.
9319	Bangor. Thompson Implement & Seed Co.
9397	Belfast. A. A. Howes & Co. Thomas W. Emerson Co., Boston, Mass.
9144	Biddeford. Biddeford Farmers'' Union. N. Wertheimer & Sons, Ligonier, Ind.
9345	Bucksport. R. C. Marks. R. B. Dunning & Co., Bangor, Maine.
9194	Kennebunk. George E. Cousens. Kendall & Whitney, Portland, Maine.
9199	Kennebunk. George W. Larrabee & Co. Jos. Breck & Sons, Boston, Mass.
9221	Lewiston. E. P. Ham. Wm. G. Scarlet & Co., Baltimore, Md.
9170	Lincoln. Lincoln Farmers' Union. Albert Dickinson Co., Chicago, Ill.
9128	Monmouth. Highmoor Farm.
9204	North Berwick. Johnson Bros. Kendall & Whitney, Portland, Maine.
9239	Norway. Norway Farmers' Union. Whitney Eckstein Seed Co., Buffalo, N. Y.
9236	Norway Lake. Norway Lake Supply Co. Haskell Implement & Seed Co., Lewiston
9377	Rockland. L. N. Littlehale Co. Whitney Eckstein Co., Buffalo, N. Y.
913[illegible]	Saco. Saco Grain & Milling Co. Kendall & Whitney Co., Portland, Maine.
94[illegible]7	Skowhegan. Skowhegan Farmers' Union. Kendall & Whitney, Portland, Me.
9414	Skowhegan. Steward & Smiley. Gerrish & Smith, Waterville, Maine.
9385	Warren. A. &. P. D. Starrett. Haskell Implement & Seed Co., Lewiston, Me.
9172	Westbrook. Westbrook Farmers' Union. Patrons' Cooperative Corporation, Portland, Maine.
9373	Wiscasset. Wiscasset Grain Co. Wm. G. Scarlett & Co., Baltimore, Md.
	RYE.
9228	Auburn. Oscar Holway Co. C. E. De Puy Co., Pontiac, Mich.
9329	Bangor. Bangor Farmers' Union. Thos. W. Emerson Co., Boston, Mass.
9362	Bangor. R. B. Dunning & Co. W. H. Morehouse & Co., Toledo, Ohio.
	SHEEP FESCUE.
9354	Bangor. R. B. Dunning & Co. Nungesser Dickinson Co., New York.
	SIBERIAN MILLET.
9348	Bangor. R. B. Dunning & Co. Albert Dickinson, Chicago, Ill.
9418	Skowhegan. E. L. & A. Gerald.

Results of Examination of Official Seed Samples, 1920.

	PURITY		IMPURITIES			NOXIOUS SEEDS		GERMINATION		
Station number.	Guaranty.	Found.	Inert Matter.	Harmless Seeds.	Weed Seeds.	Declared?	Number Found in One Pound	Guaranty.	Found.	Actual Value.*
	%	%	%	%	%			%	%	%
9295	99.0	92.9	0.6	1.7	4.8	No	Ribgrass 300, chicory 200.	96.0	81.1	75.3
9296	99.0	96.7	0.4	1.0	1.9	No	Mustard 100, curled dock 100, night flowering catchfly 100.	90.0	81.9	79.2
9384	98.0	98.4	----	----	----	No	Ribgrass 1000, night flowering catchfly 500.	00.0	75.6	74.4
9174	00.0	98.0	0.4	0.8	0.8	No	Common sow thistle 100, ribgrass 100.	90.0	91.6	89.8
9371	94.1	94.5	----	----	----	Yes	Ribgrass 4500.	91.7	91.5	86.4
9355	91.0	93.8	----	6.2	----	No	None.	90.0	29.0	27.2
9229	90.0	91.4	5.0	2.4	1.2	No	None.	60.2	72.5	66.2
9326	00.0	90.2	7.4	1.6	0.8	No	None.	90.0	83.2	75.0
9341	90.0	92.4	6.2	0.2	1.2	No	None.	90.0	88.0	81.3
9319	90.0	90.8	7.4	1.0	0.8	No	None.	77.0	61.0	55.3
9397	90.0	89.4	7.2	2.6	0.8	No	Daisy fleabane 1000.	90.0	83.7	74.8
9144	90.0	93.2	5.8	0.2	0.8	No	None.	00.0	90.5	84.3
9345	90.0	90.8	7.2	1.2	0.8	No	Daisy fleabane 1000.	00.0	82.0	74.4
9194	90.0	91.6	6.4	1.4	0.6	No	None.	00.0	58.2	53.3
9199	90.0	92.6	6.0	0.8	0.6	No	Daisy fleabane 1000.	90.0	61.5	56.9
9221	92.7	94.2	5.0	----	0.8	No	Daisy fleabane 1000.	80.5	85.2	80.3
9170	90.0	89.6	7.8	1.4	----	Yes	Daisy fleabane 1000.	90.0	77.2	69.2
9128	98.0	98.9	0.6	0.2	0.3	No	None.	92.0	92.0	90.9
9204	90.0	90.2	7.0	1.6	1.2	No	None.	90.0	55.7	50.0
9239	90.0	92.0	6.2	1.0	0.8	No	None.	90.0	81.0	74.5
9236	90.0	89.6	6.6	2.0	1.8	Yes	Daisy fleabane 1000.	90.0	74.5	66.7
9377	90.0	92.2	6.8	----	1.0	No	None.	90.0	90.2	83.2
9136	90.0	90.8	7.2	0.8	1.2	Yes	Daisy fleabane 1000.	90.0	70.5	64.0
9407	90.0	89.4	7.4	2.2	1.0	No	None.	90.0	77.0	68.8
9414	90.0	92.2	6.8	0.4	0.6	No	None.	90.0	86.7	79.9
9385	90.0	91.8	5.6	1.8	0.8	No	Daisy fleabane 1000.	92.0	80.0	73.4
9172	90.0	89.8	6.0	2.6	1.6	No	Daisy fleabane 1000.	90.0	78.0	70.0
9373	92.3	93.0	6.6	0.2	0.2	No	None.	74.0	53.2	49.5
9228	97.2	96.7	3.2	----	----	No	None.	95.5	98.0	94.8
9329	98.0	99.5	0.4	----	----	No	Curled dock 20.	95.0	96.0	95.5
9362	98.0	99.0	0.9	----	----	No	None.	95.0	96.0	95.0
9354	95.0	95.4	----	4.6	----	No	None.	89.0	46.5	44.3
9348	95.0	97.7	----	----	----	No	Ragweed 500.	90.0	85.5	83.5
9418	98.0	99.2	----	----	----	No	None.	00.0	91.5	90.8

*Obtained by multiplying per cent purity by per cent germination.

Descriptive List of Official Seed Samples, 1920.

Station number.	Kind of Seed. Name and Place of Business of Retailer and Jobber.
	SOUDAN GRASS.
9367	Bangor. R. B. Dunning & Co. Nungesser Dickinson Co., New York
	SWEET CLOVER.
9357	Bangor. R. B. Dunning & Co. Nungesser Dickinson Co., New York
	TIMOTHY.
9080	Ashland. H. B. Bartlett & Co.
9243	Auburn. Oscar Holway Co. Albert Dickinson Co., Chicago, Ill.
9244	Auburn. Oscar Holway Co.
9323	Bangor. Bangor Farmers' Union. H. W. Doughten Inc., Phil., New York, Syracuse
9325	Bangor. Bangor Farmers' Union. Thos. W. Emerson Co., Boston, Mass.
9335	Bangor. H. A. Dunning. Oscar Holway Co., Auburn, Maine
9249	Bath. Bath Grain Co.
9206	Berwick. J. A. Tibbetts. Thompson & Hoague Co., Concord, N. H.
9143	Biddeford. Biddeford Farmers' Union. N. Wertheimer & Sons, Ligonier, Ind.
9262	Bridgewater. Fred W. Snow. E. W. Conklin & Son, Binghamton, N. Y.
9264	Bridgewater. A. M. Stackpole. John Watson & Co., Houlton, Maine
9343	Bucksport. R. C. Marks. R. B. Dunning & Co., Bangor, Maine
9386	Camden. Camden Farmers' Union. Orman Keene, North Appleton, Maine
9300	Caribou. Caribou Grange Store. Nungesser Dickinson Seed Co., New York
9305	Caribou. Mitton, Poland & Bishop. Albert Dickinson Co., Chicago, Ill.
9375	Damariscotta. G. E. Gay. Kendall & Whitney, Portland, Maine
9155	Danforth. H. H. Putnam. R. B. Dunning & Co. Bangor, Maine
9269	Fort Fairfield. Ames & Hacker. Albert Dickinson Co., Chicago, Ill.
9272	Fort Fairfield. S. Nightingale & Son. Oscar Holway Co., Auburn, Maine
9283	Fort Kent. Fred Michaud. Oscar Holway Co., Auburn, Maine
9285	Fort Kent. Philippe A. Roy. R. B. Dunning & Co., Bangor, Maine
9035	Houlton. John Watson & Co.
9100	Houlton. John Watson & Co.
9115	Houlton. John Watson & Co.
9307	Island Falls. Island Falls Grange Store. Oscar Holway Co., Auburn, Me.
9193	Kennebunk. George E. Cousens. Kendall & Whitney, Portland, Maine
9200	Kennebunk. George W. Larrabee & Co. Jos. Breck & Son, Boston, Mass.
9219	Lewiston. E. P. Ham. Wm. G. Scarlett Co., Baltimore, Md.
9167	Lincoln Lincoln Farmers' Union. Albert Dickinson Co., Chicago, Ill.
9153	Milltown. S. S. Pineo. C. M. Conant Co., Bangor, Maine
9126	Monmouth. Highmoor Farm
9205	North Berwick. Johnson Bros. Kendall & Whitney, Portland, Maine
9238	Norway. Norway Farmers' Union. Whitney Eckstein Seed Co., Buffalo, N. Y.
9121	Presque Isle. E. W. Fernald
9122	Presque Isle. E. W. Fernald
9379	Rockland. L. N. Littlehale Co. Whitney Eckstein Seed Co., Buffalo, N. Y.
9140	Saco. Saco Grain & Milling Co. Kendall & Whitney, Portland, Maine

Results of Examination of Official Seed Samples, 1920.

	Purity		Impurities			Noxious Seeds		Germination		
Station number.	Guaranty. %	Found. %	Inert Matter. %	Harmless Seeds. %	Weed Seeds. %	Declared?	Number Found in One Pound	Guaranty. %	Found. %	Actual Value.* %
9367	90.0	95.2	4.5	0.3	----	No	None.	85.0	78.0	74.2
9357	98.0	97.8	----	----	----	No	Wild carrot 1500.	90.0	70.0	68.4
9080	99.5	99.6	0.2	0.1	0.1	No	None.	90.0	94.7	94.3
9243	99.2	99.4	----	----	----	No	None.	92.0	93.0	92.4
9244	99.6	99.7	----	----	----	No	None.	96.0	93.5	93.2
9323	99.6	99.1	----	----	----	No	None.	00.0	87.7	86.9
9325	99.0	99.5	----	0.5	----	No	None.	95.0	93.5	93.0
9335	98.0	98.8	----	1.2	----	No	None.	90.0	90.0	88.9
9249	99.5	99.4	----	----	----	No	None.	92.0	91.2	90.7
9206	99.6	99.6	----	0.4	----	No	None.	95.0	91.7	91.3
9143	99.5	99.5	0.2	0.2	0.1	No	None.	00.0	94.5	94.0
9262	99.6	99.6	----	----	----	No	None.	93.0	85.2	84.9
9264	99.6	99.7	----	----	----	No	None.	96.0	92.7	92.4
9343	99.5	99.6	----	----	----	No	None.	00.0	90.7	90.3
9386	99.7	99.4	----	----	----	No	None.	94.0	94.2	93.6
9300	00.0	99.6	----	----	----	No	None.	00.0	91.0	90.6
9305	99.6	99.6	----	----	----	No	None.	95.0	89.0	88.6
9375	98.0	98.5	----	----	----	No	None.	93.0	90.0	88.6
9155	99.5	99.7	----	----	----	No	None.	93.0	88.5	88.2
9269	99.5	99.8	----	----	----	No	None.	95.0	91.5	91.3
9272	99.2	99.3	----	----	----	No	None.	92.0	90.0	89.3
9283	99.6	99.6	----	----	----	No	None.	97.0	92.2	91.8
9285	99.5	99.7	----	----	----	No	None.	95.0	92.5	92.2
9035	99.5	99.6	0.2	0.1	0.1	No	None.	94.0	93.7	93.3
9100	99.6	99.6	0.1	0.2	0.1	No	None.	96.0	93.5	93.1
9115	99.6	99.6	0.2	0.1	0.1	No	None.	95.0	93.5	93.1
9307	99.6	99.7	----	----	----	No	None.	97.0	92.0	91.7
9193	98.0	98.8	----	----	----	No	None.	00.0	82.0	81.0
9200	99.0	99.3	----	----	----	No	None.	96.0	95.5	94.8
9219	99.6	99.6	0.2	0.1	0.1	No	None.	92.0	90.5	90.1
9167	99.7	99.4	0.3	0.2	0.1	No	Curled dock 100.	94.0	97.0	96.4
9153	99.5	99.6	----	----	----	No	None.	94.0	90.2	89.8
9126	99.5	99.6	0.2	0.1	0.1	No	None.	93.0	91.7	91.3
9205	98.0	98.4	----	1.6	----	No	None.	92.0	89.2	87.8
9238	99.5	99.4	----	----	----	No	None.	94.0	90.5	89.9
9121	99.8	99.7	0.1	0.1	0.1	No	None.	90.0	71.2	71.0
9122	99.5	99.5	0.2	0.2	0.1	No	None.	98.5	95.7	95.2
9379	99.5	99.6	----	----	----	No	None.	96.0	94.7	94.3
9140	98.0	98.2	----	1.8	----	No	None.	93.0	87.7	86.1

*Obtained by multiplying per cent purity by per cent germination.

Descriptive List of Official Seed Samples, 1920.

Station number.	Kind of Seed. Name and Place of Business of Retailer and Jobber.
9182	Sanford. O. W. Brown & Son. Kendall & Whitney, Portland, Maine
9189	Sanford. S. J. Nowell. Kendall & Whitney, Portland, Maine
9178	Springvale. W. H. Sherburne. Kendall & Whitney, Portland, Maine
9291	Van Buren. H. A. Gagnon. Stanford Seed Co., Binghamton, N. Y.
9289	Van Buren. W. F. Paradis. The Stanford Seed Co. Inc., Binghamton, N. Y.
9290	Van Buren. W. F. Paradis. The Stanford Seed Co., Binghamton, N. Y.
9288	Van Buren. Fred J. Parent. R. B. Dunning & Co., Bangor Maine
9281	Waldoboro. J. T. Gay. Whitney Eckstein Seed Co., Buffalo, N. Y.
9171	Westbrook. J. W. Morris. Kendall & Whitney, Portland, Maine
9173	Westbrook. Westbrook Farmers' Union. Patron's Cooperative Corporation, Portland, Maine
9176	West Gorham. J. S. Watson. Kendall & Whitney, Portland, Maine
9372	Wiscasset. Wiscasset Grain Co. Wm. G. Scarlett & Co., Baltimore, Md.
	SPRING WHEAT.
9363	Bangor. R. B. Dunning & Co. Albert Dickinson, Chicago, Ill.
9317	Bangor. Thompson Implement & Seed Co. Dr. Clough, Bangor, Maine
9391	Camden. J. C. Curtis Co. Kendall & Whitney Co., Portland, Maine
9260	Houlton. John Watson & Co.
9137	Saco. Saco Grain & Milling Co. Whitney Eckstein Seed Co., Buffalo, N. Y.
	WHITE CLOVER.
9190	Kennebunk. George E. Cousens. Kendall & Whitney, Portland, Maine
9203	Kennebunk. George W. Larrabee & Co. Jos. Breck & Sons, Boston, Mass.
9181	Sanford. O. W. Brown & Son. Kendall & Whitney, Portland, Maine
9187	Sanford. S. J. Nowell. Kendall & Whitney, Portland, Maine

Results of Examination of Official Seed Samples, 1920.

	PURITY		IMPURITIES			NOXIOUS SEEDS		GERMINATION		
Station number	Guaranty. %	Found. %	Inert Matter. %	Harmless Seeds. %	Weed Seeds. %	Declared?	Number Found in One Pound	Guaranty. %	Found. %	Actual Value.* %
9182	98.0	98.4	----	1.6	----	No	None.	93.0	90.0	88.5
9189	00.0	99.7	----	----	----	No	None.	00.0	87.5	87.2
9178	99.5	99.6	----	----	----	No	None.	92.0	98.0	97.6
9291	99.5	99.8	----	----	----	No	None.	93.0	89.0	88.8
9289	99.5	99.3	----	----	----	No	None.	95.0	94.5	93.8
9290	99.5	99.7	----	----	----	No	None.	93.0	91.2	90.9
9288	99.5	99.5	----	----	----	No	None.	93.0	93.7	93.2
9381	99.5	99.5	----	----	----	No	None.	90.0	85.2	84.8
9171	98.0	98.5	----	----	----	No	Small false flax 500.	93.0	79.2	78.0
9173	95.5	99.6	----	----	----	No	None.	90.0	97.2	96.8
9176	99.7	99.5	----	----	----	No	None.	96.0	94.2	93.7
9372	94.1	94.5	----	----	----	No	None.	95.0	91.2	86.3
9363	99.0	98.6	0.9	0.3	0.1	No	Ball mustard 30.	95.0	91.0	89.7
9317	99.4	99.3	0.4	0.1	0.0	No	None.	98.0	99.0	98.3
9391	98.0	99.5	0.4	----	----	No	None.	95.0	97.5	97.0
9260	00.0	94.1	4.3	1.1	0.3	No	Ball mustard 60, black mustard 40, giant ragweed 30, hare's ear 10.	00.0	88.0	82.8
9137	98.0	99.6	0.2	0.1	----	No	None.	90.0	100.0	99.6
9190	94.0	95.2	----	----	----	No	Night flowering cacthfly 500.	75.0	55.7	53.0
9203	96.0	96.8	----	----	----	No	None.	00.0	51.0	49.3
9181	94.0	96.0	----	----	----	No	None.	75.0	53.2	51.1
9187	96.0	96.5	----	----	----	No	None.	92.0	57.0	55.0

*Obtained by multiplying per cent purity by per cent germination.

INDEX TO ANALYSIS OF SEEDS EXAMINED